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Conducted by MAJOR B. BADEN-POWELL, F.R.A.S., and E. S. GREW, M.A.

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Lightning Flashes from Earth to Cloud.

By WILLIAM J. S. LOCKYER, M.A., Ph.D., F.R.A.S.

" Ah, Thomas,
" That lightnings that we think are only Heaven's,
" Flash sometimes out of Earth against the sky."
Tennyson, *Becket*.

As long ago as the year 1856 James Nasmyth remarked (British Association Report, 1856, p. 14) that in many cases of lightning flashes which he minutely observed the course of the flash was from the earth *upwards* towards the heavens.

Again Dr. T. L. Phipson (Familiar Letters, &c., 1876, p. 195) mentions that Admiral FitzRoy describes a thunderstorm off the coast of La Plata when the whole heavens appeared like a metal foundry so numerous were the flashes. Neither his own ship nor another about a mile distant were struck, but the sea between them was several times, and in one instance the lightning appeared to rise from the surface of the water. Dr. Phipson, in another place, also wrote that " a few cases are on record of these upward strokes of lightning in various authors."

Another case of the observation of an earth-to-cloud flash is that which was communicated to me by my friend, Mr. Seymour H. Beale, of Banbury, in relation to a thunderstorm which occurred in that town on July 9, 1905.

" At 11.30 a.m. it was very hot and close with no breath of wind stirring. About noon distant thunder was heard, which continued until 12.20 p.m., when the clouds took a fearful shape, but were not very dense. Then came an enormous *upward* flash from the ground to the cloud (I have several times seen these upward flashes in this neighbourhood, but nowhere else), accompanied directly after by a minute downward flash quite 10 degrees to the east of it. The flash was about three miles off. . . . Then downward flashes came rapidly and vividly. . . ."

From the above it will be seen that Mr. Beale, who is a very careful observer, was distinctly able in his own mind to differentiate between upward and downward flashes, and it is interesting further to note his remark that upward flashes seemed to be special to the neighbourhood of Banbury.

The above observations, and others might be cited,

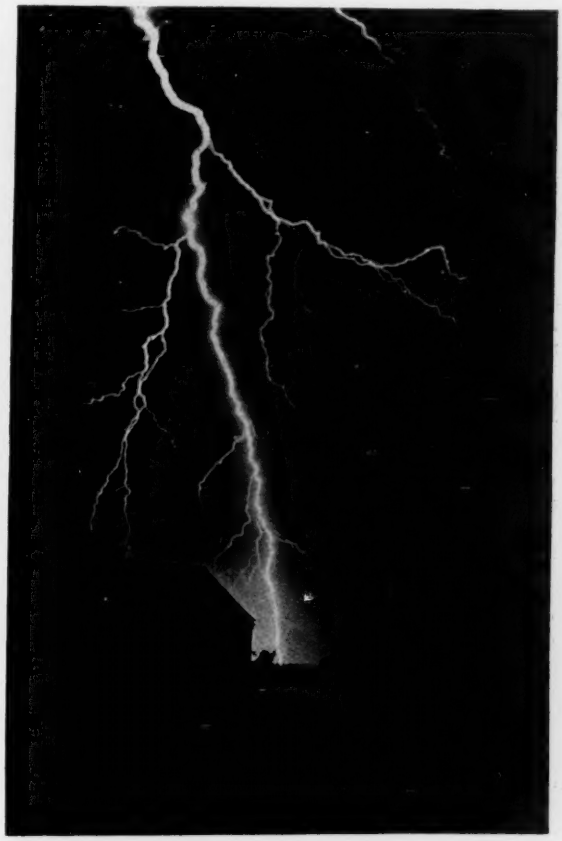


Photo by J. W. Bridges.

Fig 1.—Cloud-to-earth discharge showing the ramifications directed earthwards. August, 1906. Chadwell Heath.

indicate that flashes from earth to cloud have been definitely recorded.

Turning now to a lecture on " Thunderstorms " delivered by Prof. Tait in the Glasgow City Hall on January 29, 1880, we find that he regarded the origin

of such an observation as subjective, as can be gathered from the following extract :—

"A remark is made very commonly in thunderstorms, which, if correct, is obviously inconsistent with what I have said as to the extremely short duration of a flash. Even if we supposed the flash to be caused by a luminous body moving along, like the end of a burning stick whirled around in a dark room, it would pass with such extraordinary rapidity that the eye could not possibly follow its movements. Hence it is clear that when

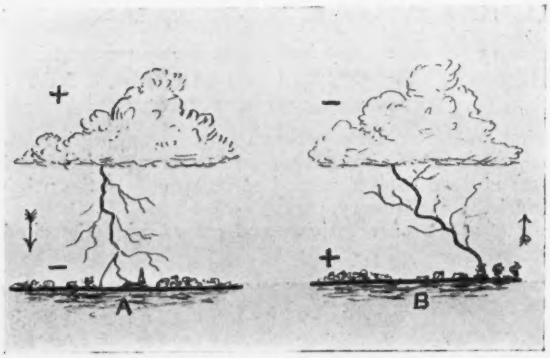


Fig. 2.—Diagram to illustrate the direction of the ramifications from the main flash when the discharge is from (A) cloud to earth and (B) earth to cloud. The main discharge is in both cases from + to −.

people say they *saw* a flash go upwards to the clouds from the ground, or downwards from the clouds to the ground, they must be mistaken. The origin of the mistake seems to be a *subjective* one, viz., that the central parts of the retina are more sensitive, by practice, than the rest, and, therefore, that the portion of the flash which is seen directly affects the brain sooner than the rest. Hence a spectator looking towards either end of a flash very naturally fancies that end to be its starting point." (Thunderstorms, p. 9.)

It will be gathered from the above extract that Prof. Tait only regards the observation of the direction of the flash as impossible, but in no way suggests that flashes from earth to cloud do not occur.

In my own case I have never been fortunate enough to observe an earth-to-cloud lightning flash, but I have very carefully observed a great number of flashes which I regarded as travelling from cloud to earth, in spite of the fact that in many instances my eye was directed towards the horizon; these flashes, according to Prof. Tait, should have been noticed by me as *upward* discharges.

Further, I have watched numerous *ramified* flashes, that is, discharges which have branches or tributaries like a river, and a strong impression has been formed in my mind that these ramifications were not quite simultaneous with the main stream. This observation can, however, be easily explained, as most probably the brightest part of the flash, the main stream, would effect the retina before the fainter portions, namely, the ramifications.

The examination of a large number of photographs of ramified flashes taken with *moving* cameras has convinced me that my impression of the apparent lateness in the appearance of the ramifications was incorrect. The photographs indicate that they occur simultaneous with the main stream, since they are joined to, and not separated from, the chief channel of discharge. An example of such a photograph will be seen in the left-hand flash shown in Fig. 7 (this figure will appear in the second part of this article), which was taken by a camera rapidly moving from left to right horizontally.

One cannot, however, be too careful in checking eye observations and impressions by photographic methods whenever possible, and it is in this respect that the camera is such a valuable aid to science. The eye gives us only a temporary view, which is gone for ever, but the photographic plate provides us with a lasting record, which can be studied at leisure.

Assuming, therefore, that the eye is not able to detect the direction in which a single flash is proceeding, owing to the extreme rapidity of travel of the electric current, a way is open to us, I think, of determining by photography whether a flash is going from earth to cloud or from cloud to earth, with the proviso that the discharge has ramifications.

If we turn our attention for a moment to the action of an electrical machine, we find that when a spark is made to pass from one pole to another, the ramifications from the main spark are always in a certain direction, namely, from the positive to the negative pole, *i.e.*, in the general direction of the main discharge. In fact, as Prof. Silvanus Thompson states in his excellent "Elementary Lessons in Electricity and Magnetism" (Edition 1895, p. 303), "the branches always point towards the negative electrode."

If anyone makes a study of the direction of ramifications in photographs of lightning, he will find that the ramifications are directed earthwards in about ninety-nine cases out of every hundred. The accompanying illustration (Fig. 1) gives an example of such a discharge, and is a reproduction from a photograph taken by Mr. J. W. Bridges in August, 1906. The deduction to be made from this fact is that in most cases the

Photo by Mr. James Crosbie.

Fig. 3. A discharge which has the appearance of a flash from earth to cloud. This is, however, very probably only an effect of perspective. Erith, 1894.

discharge is a cloud-to-earth one, and, therefore, the cloud is the positive and the earth the negative pole.

It can, and does, happen, however, that clouds may be negatively charged, and this has often been made apparent to us by flashes of lightning passing between cloud and cloud.

The question now arises, Can the earth become positive, or, in other words, can a lightning flash be an earth-to-cloud discharge? This question, I think, is answered by the few photographs which accompany this

article, for the ramifications in each case are all directed cloudwards and not earthwards.

It may be useful to show diagrammatically (Fig. 2) the two main conditions mentioned above, namely, (*a*) when the cloud is positive and the earth negative (the common case); and (*b*) when the signs are reversed (the exceptional case); the arrows indicate the direction of travel of the current in each case.

It will then be seen that the general trend of the branches indicates the direction of the discharge, and this can be determined as easily by the eye as it can be recorded by the photographic plate. The reader's attention will, however, here be restricted to photographs alone, for they can be examined at leisure. Although I have examined some two hundred photographs of lightning flashes, I have only come across two which, in my opinion, are, without doubt, earth-to-cloud discharges, one of them, which shows two such flashes, being a nearly perfect example. The third photograph represents also, I believe, an upward discharge, but it *may* be an exceptional effect of perspective upon a cloud-to-earth flash. One has to be exceedingly careful in differentiating between photographs of true earth-to-cloud discharges, and those which appear like them, but are really due to an effect of perspective. Several photographs which I have examined appeared to indicate an upward trend of the ramifications, but in nearly every case the directions of the branches could be explained without difficulty in the above manner.

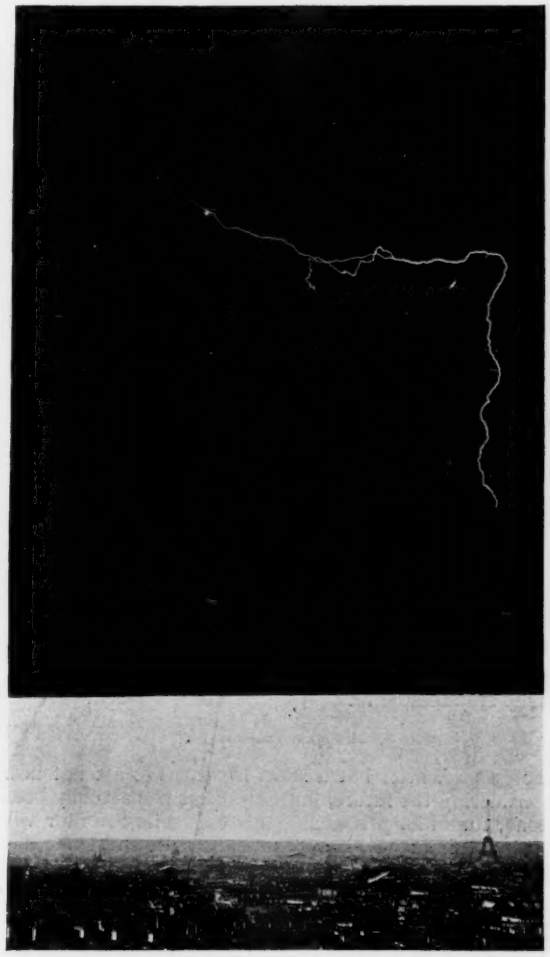


Photo by Monsieur G. Mesmer.

Fig. 4.—A lighting flash from the Eiffel Tower to a cloud. Paris, July 31, 1904.

It is, therefore, important to treat as typical cases of earth-to-cloud flashes only those photographs which show the earth and cloud ends of the flashes in the field of view of the camera. This means, therefore, that such photographs can only be secured when the flashes are some distance away from the photographer.

A case of a very probable perspective effect of a cloud-to-earth flash is that shown in Fig. 3. This excellent photograph was taken by Mr. James Crosbie, of Erith, in 1894. The flash commences in a cloud some distance away behind the trees, and comes towards the observer. The single stream, which, in the first instance, is thin, because the flash is so far distant, splits up into two branches, as the observer is approached; each of these becomes more intense, and, therefore, broader, because they are getting nearer the observer. The flash probably reached earth somewhere behind the photographer. The ramification towards the right of the photograph has also a direction inclined rather towards the camera, but it was apparently dissipated before it reached earth.

Coming now to the first of the earth-to-cloud photographs, we have an excellent example in the interesting flash shown in Fig. 4. This was taken by Monsieur G. Mesmer at Paris on July 31, 1904, at 11h. 45m. p.m. The upper portion of the picture was the actual photograph secured, but owing to the faintness of the landscape in the original negative, a similar view was taken by him the next day from the same position with the same camera. This view has been placed exactly below in the illustration, so that the top of the tower should be imagined to be at the lower extremity of the flash.

The flash itself emanated from the top of the Eiffel Tower. It made a sinuous path upwards, and then evidently met a stratum of air through which it could not easily pass; this caused it to alter its direction (towards the left in the photograph). The flash then split itself into two, each of the branches becoming fainter and eventually discharging themselves in the clouds in the upper air.

It seems to me more easy to explain the peculiarity of this flash as an earth-to-cloud discharge than to imagine the probability of two flashes meeting together in the air and pursuing the same track to the earth.

It may be of interest to the reader to know that when I suggested to Monsieur Mesmer that this flash was of a peculiar nature and I felt bound to consider it as an earth-to-cloud discharge, he wrote :—

"Your remark on the subject of the flash with an upper bifurcation appears to me quite correct. It is manifest that this discharge ought to be directed from the Eiffel Tower towards the clouds. I had not remarked this peculiar character of this flash, and Monsieur Emile Touchet, to whom I have sent a print of this photograph at the same time as the others which have been published, has also doubtless not perceived it, as he did not mention it to me. What did appear remarkable to me about this flash was that it was visible in the whole of its development (from beginning to end), and struck, or rather flowed, from a well-known terrestrial object. . . ."

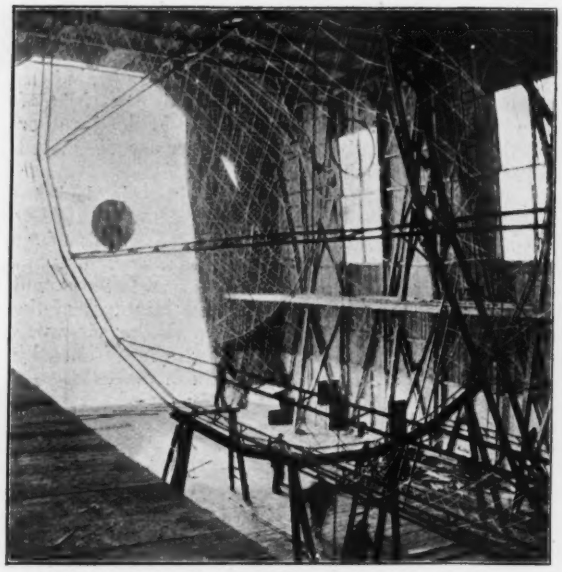
(To be continued.)

The Latest Developments in Aerial Navigation.

By MAJOR BADEN-POWELL.

DURING the last month or so several important advances have been made towards the conquest of the air, and the subject has been much "boomed" in the daily Press. An important lecture dealing with the matter was given on November 15, by Colonel Fullerton, R.E., before the Royal United Service Institution.

Santos Dumont has, as usual, been well to the fore, and has attracted the attention of the multitude. But it may be said at once that, as on previous occasions,



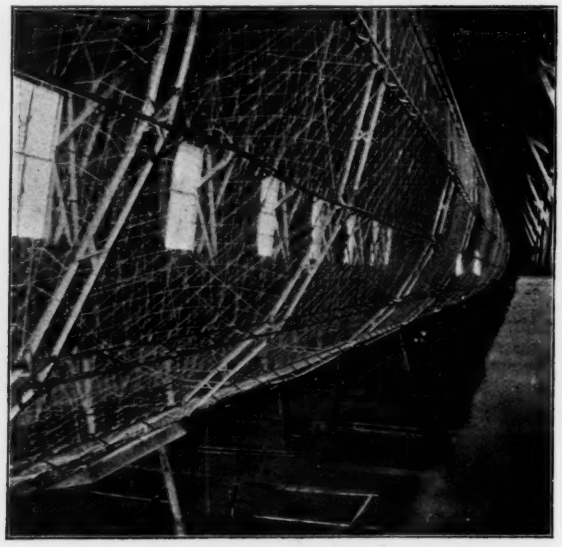
Zeppelin Airship—The Bows.

his exploits have been glorified quite beyond their real significance. Many of the papers have hailed this inventor as the first man to fly, ignoring the many attempts that have hitherto been made with almost as much success, and quite forgetting the very brilliant achievements of the Brothers Wright, who have far surpassed anything that Santos Dumont, up to the time of writing, has accomplished. It may, perhaps, be of interest to briefly recapitulate the known occasions on which men have been raised off the ground by machines of the "heavier-than-air" type. Apart from gliding machines, which are not intended to rise by any inherent power, there are three machines that we know of, besides those mentioned, that are supposed to have risen off the ground, lifting their entire weight. The first is that of Sir Hiram Maxim. In 1894, this huge machine was travelling along its railway track at a rate of some 40 miles an hour, when it broke loose, and made something of a jump through the air before falling to the ground. We need not now re-open the discussion as to whether or not this can be considered as a true flight. For the moment all we need be concerned with is as to whether a machine carrying a man or men has risen off the ground. Later on we will draw the distinction between this and true flight. The next event worth chronicling was the trial of M. Ader's apparatus, in 1897, which is said to have risen with its inventor aboard, and travelled for some yards through the air. The third ascent of a man-carrying machine was in 1901, when Herr Kress rose, with a system of aeroplanes, from the surface of a lake, but fell back into it.

These efforts can, however, hardly be considered as really successful flights, but they clearly prove that a machine on the aeroplane principle, if propelled by sufficiently powerful propellers, can rise off the ground and lift human beings with it. This is an important point, since many writers have cast doubt on the possibility of being able to accomplish even this much.

Stability while progressing through the air is another matter altogether. Experiments with models prove it to be a problem involving many complications and difficulties. It is, at present, very doubtful if M. Santos Dumont has solved to any great extent this problem.

His machine has on each occasion fallen heavily to



The Main Framework.

the ground, after but a short flight. We are not now considering the future, but only what has actually been done, for in all probability this energetic inventor will bit by bit improve his apparatus so as to overcome any tendency it may have to upset. Still, so far, he has not done more than to improve slightly on the experiments referred to. This machine, it may be as well to mention, consists of two superposed aeroplanes, slightly concave on the under side, 39 feet across, and 11 feet wide, being 7 feet apart, and divided into compartments by six vertical divisions. These planes are placed at a slight diedral angle, and the area is reckoned as 861 square feet. From the front of the lower plane extends a long, box-like tube, supporting a box to act as rudder. A 50-horse power Antoinette motor is now used, replacing an older one of 24-horse power. This rotates a single two-bladed screw propeller, six feet in diameter, in rear of the centre. The propeller is connected direct to the motor shaft, which turns it at a rate of 1,500 revolutions per minute, and is said to give a thrust of 330 lbs. The total weight lifted is put at 650 lbs.

While public interest is, for the moment, absorbed in the thought of the attainment of flight on the heavier-than-air principle, two very marked advances have been

made with propelled balloons, and if such machines are not to be considered as the ultimate ideal of aerial navigation, yet improvements have now been accomplished in their construction, such as to render them practical engines of war. Count von Zeppelin, the veteran German general, who has for so many years been pluckily striving against difficulties and misfortune, has at last acheived unqualified success with his immense airship. This apparatus, as re-constructed, consists of a huge frame-work of aluminium, 430 feet long, over which a smooth outer covering is arranged, and within which, 15 balloons are placed. The two separate engines are each of 85-horse power, working four small screws, placed on each side of the vessel.

The photographs which we reproduce, are of special interest, as having been taken during the process of building the machine, and never before published. They clearly show many of the details of construction. Immense hoops, about 36 feet in diameter, are constructed of lattice girder-work of aluminium, rivetted together. These are all connected together with a series of longitudinal girders of similar construction. Over this framework is tightly stretched a netting of hemp cord, both inside and outside, so as to make two layers of netting to allow a space between the inner and outer skins. The vessel is further stiffened by transverse nettings, forming partitions to keep the internal balloons apart. Over the whole, an outer varnished silk covering is tightly stretched, so as to form a smooth surface to drive through the air. The general shape, as is well-known, is a long cylinder with ogival ends. The extreme point of the bow is formed of a hemispherical aluminium cap, and may be noticed in one of the photographs, where it appears against the light of the sky, almost as if unsupported.

This vast airship underwent many vicissitudes, and was several times reconstructed, but on the 9th of October last, it rose from its platform on Lake Constance, remained for about two hours in the air, manœuvring over the lake, and finally, returned safely to its shed. The maximum speed (taken accurately by theodolites) was 12 metres per second, or just on 30 miles an hour. It has often been remarked that the real test of the practicability of an airship is its ability to attain a sufficient speed to stem any ordinary wind. A speed of 30 miles an hour should certainly be sufficient for this, and even if the machine is not capable of progressing against a strong wind, still it should be able to manœuvre on any average day.

The third machine to successfully take the air is the new Lebaudy, "La Patrie," which has been built to the order of the French Government. This is, in general arrangement, very similar to the last Lebaudy, but incorporates many minor improvements. The volume is 3,200 cubic metres, and the engines, of Panhard make, develop 75-horse power.

On November 16, she made her first trial trip, remaining two hours and 20 minutes in the air, and attaining a speed said to be 20 miles an hour. Six passengers were on board. Since then further trials have been made with complete satisfaction, the greatest speed attained being given as 28 miles an hour. Considering the remarkable performances of the first Lebaudy, it is to be hoped that this vessel will prove thoroughly serviceable.

Thus both the French and the German armed forces may now be considered to include aerial machines. It is already rumoured that the French are building more, and. without doubt, the Germans and other nations will quickly follow suit.

The Flight of Flying Fishes.

Lt.-Col. Durnford's Arguments.

FROM Lieut.-Col. C. D. Durnford we have received a copy of the second paper which he has contributed to the *Annals and Magazine of Natural History* on "The Flying Fish Problem." Lieut.-Col. Durnford, as readers of the Natural History Notes will be aware, is the opponent of the aëroplane theory of the flying fish's flight, and believes that the flight is accomplished by a very rapid movement of its fin-wings. In a paper published last January he endeavoured to show that the wing surface of a flying fish was not great enough to support the weight of a flying fish considered as an aëroplane. "The argument was based," to quote the paper before us, "upon the fact that as a flying animal the flying fish is equipped with wings of a fractional sailing value compared with those of a sailing bird. Also that if the wings were many times larger, so as to bring the fish on an equality with the bird in this respect, it could only sail with the bird's limitations as regards direction of the wind, and with the bird's frequent assistance from rowing flight."

The difficulty of deciding the vexed question appears to have arisen from the fact that many people, perhaps most people, are unable to perceive the motion of the wings. By Lieut.-Col. Durnford this is attributed to defects of vision, and he remarks that he himself and other witnesses are able to see the movement. One of his latest witnesses has had abundant opportunities of observation during the last year. In a paper dated October, 28, 1905, Brig *Galilee*, North Pacific Ocean, Dr. J. H. Egbert, Carnegie Expedition, writes: "Though still denied by some observers, the power of propulsion through the air by means of its fin-wings is generally accorded the flying fish. During months at sea in the tropics the writer has almost daily watched the flying fishes and studied their flight through the air. . . . The difficulties of assuring oneself that the flying fish moves its wings during its flight through the air are well understood, and also the fact that these difficulties are generally removed when opportunity is afforded of observing the flight of certain of the larger species under favourable conditions. That flying fishes use their wings after the manner of birds, at least upon emerging from the water, can hardly be denied, since from the forecastle head of a ship plying the waters of the lower latitudes this wide birdlike motion of the fin-wings may be easily observed as the large flying fishes break water almost under the vessel's bow. This flapping motion of the fin-wings is not, however, long maintained, but as soon as the fish is well started in the air apparently passes into a vibratory motion of the appendages so rapid as to be almost beyond human visual perception."

Mr. Lionel E. Adams (*Zoologist*, April 4, 1906) is another witness in favour of Lieut.-Col. Durnford's beliefs; and, to a slighter extent, Mr. F. G. Aflalo. But the circumstance in which Lieut.-Col. Durnford relies is less that of the perception of the wing movement by observers, than on the impossibility that an aëroplane, whether it were in the form of a bird, a bat, or a flying fish, could glide with and against the wind and at an angle with the wind, and describing curves which would bring it round in a semi-circle—unless it were propelled by some wing-flapping motion. The follow-

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ing is, he thinks, probably a fair description of the flying fish's methods in an ordinary flight :—

1. The tail impelled and visibly wing assisted jump from the water to a height where the wings can work freely.

2. The flight continued by an intensely rapid and laboured wing-movement—one easily mistaken for stillness, and usually seen, if at all, as blurr.

3. Short periods of slowing down of wing-speed, during which the wing-movement becomes again visible. (These are the "vibration" periods, representing to aëroplanists loose wing-trailing, or dragging like a flapping flag—an impossibility.) These periods often precede a special spurt such as is required to lift the fish over an oncoming wave.

4. Either sudden cessation of wing-movement and consequent immediate drop into the sea, or a short slow down into visibility (No. 3) previous to such drop.

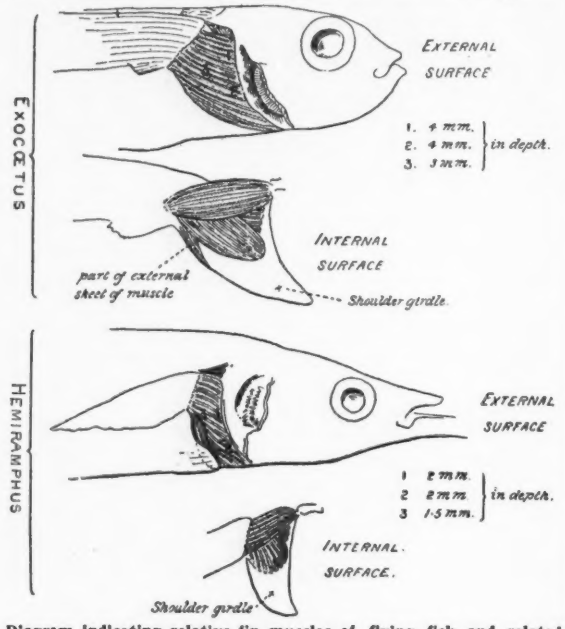

Diagram indicating relative fin muscles of flying fish and related species.

"It is to be noted that this vibration so often seen before the fish enters the water is one of the many pointers to continuous wing-movement, for such a time is a proper one for slowing down, but an absurd one for renewal of wing-effort. Mr. Adams has noticed the vibration of the wings as being in "an almost horizontal direction." This horizontal movement, if it exists, as is probable, may afford, as I hope to show, a looked-for key to the fish's action. According to Pettigrew, it is a necessity of flight, where wing-beats are in a more or less vertical direction, that the up-beat should meet with little and the down-beat with much resistance from the air. This is arranged for in the case of bats, birds, and certain insects by means of special muscles and ligaments, which automatically flex the wing for or during the up-stroke and extend it for or during the down. Marey (*Animal Mechanism*, p. 263, &c. : Int. Science Series, 1893) equally recognises the necessity for a diminished wing-area in the up-stroke, but believes it to be obtained in birds through the natural elasticity of the feathers, which enables them to return to their ordinary position when the resistance of the air in the down-stroke ceases to raise them. The flying fish's wing, as is known, is formed on quite a different principle from that of a bird or bat. It opens and closes somewhat like a fan. A partial automatic closing of this fan at the foot of the downward stroke in flight and opening at the top of the rising stroke would both give the appearance of horizontal vibration when seen either from above or below, and would turn a somewhat difficult question of the mechanics of the flight into a very simple one. Indeed, we have here flying action on the same general principle as that shown by Pettigrew and Marey to be necessarily provided for in the case of bats and birds, but the working details of which are different and simpler, as becomes a simpler form of wing. Perhaps that is the explanation. There must, of course, be some explanation, and that is not only the natural deduction from the peculiar formation of the wing, but it also fits everything in. The known (but indistinct) visibility of the larger rays of the wings at times during flight points, perhaps, to a comparative pause with wings full open before beginning the down-stroke. Such pause would give the open position, and with it the wing-tracery prominence. The form of these fishes' wings points to this fan-action rather than to other known horizontal wing-actions of the nature of that of certain insects—the common fly, for instance."

Lieut.-Col. Durnford adds to his paper a letter from Mr. Burne, of the Royal College of Surgeons, who dissected at the Museum the pectoral muscles of a flying fish with those of a nearly related non-flying fish :—

". . . . I have made a dissection of the pectoral muscles of a flying fish (*Exocœtus* sp.) and of a nearly related fish of much the same build, but without the enlarged pectoral fins (*Hemiramphus*). Both were specimens from our store-room, and although in pretty good condition had evidently been in spirit for a considerable time. I enclose you tracings of the drawings I made. The two of the external view were drawn with a camera, and the *Hemiramphus*, which was rather less in girth than the *Exocœtus*, was so much enlarged as to have the same girth about an inch behind the pectorals. I thought that body-girth sufficiently far behind the fins not to be influenced by their degree of development was the best standard of size to take—better than length, for instance. As a matter of fact, the fish were very much the same length, the *Exocœtus* being rather the longer.

"The drawings, I think, explain themselves. The flying fish muscles were, as you see, considerably larger, both in area and in thickness, than in *Hemiramphus*, and the same was the case with the muscles on the deep surface of the fin. In their arrangement they were much the same in both fish and the same as in other bony fishes (the cod, for instance). The numbers on the surface of the fins are the points where I took the thickness of the muscle by plunging a needle into it and measuring the depth to which the needle entered. You will notice the great length of the muscles in *Exocœtus*—a long muscle means a proportionate length of contraction.

". . . . there is a very marked difference in the size of the muscles of these two fishes. . . ."

"This tracing," observes Lieut.-Col. Durnford, "gives about $4\frac{4}{8}$ times greater bulk of muscle to the *Exocœtus* than to the *Hemiramphus*." With this light it will not be out of place to requote and amplify the one "proof," distinguishing the addition by italics :—"The pectoral muscles of birds depressing their wings weigh on an average one-sixth the total weight of their body, the pectoral muscles of bats one-thirteenth, the muscles of

the pectoral fins of flying fish . . . . one thirty-second," *and the muscles of a nearly related non-flying fish only one hundred and fifty-fourth.*

"As before, it does not prove that bats or flying fish flap or do not flap their wings, but it gives a different and, I hope, a proper aspect to the figures which have done duty—of a kind—for so many years."

Light and the Visual Sense.

A Study in Biological Physics.

By HENRY A. FOTHERBY, D.Ph. (Camb.), L.R.C.P. (Lond.), &c.

"THE method by which a ray of light is able to stimulate the endings of the optic nerve in the retina in such a manner that the visual sensation is perceived by the cerebrum is not yet understood. It is supposed that the change effected by the agency of the light which falls upon the retina is, in fact, a chemical alteration in the protoplasm, and that this change stimulates the optic nerve endings."—(Halliburton.)

We know that the energy of light as well as heat and electricity are capable of producing chemical action. For instance, if a mixture of chlorine and hydrogen gases, which will keep indefinitely in the dark, is exposed to sunlight they will combine with explosive violence. The principle on which photography depends is the influence of light in producing chemical change in silver chloride, which becomes blackened owing to the reduction of silver. It is from the radiant energy of sunlight that chlorophyll, the green colouring matter of plants, derives chemical energy whereby plants are enabled to build up their tissues from the elements of carbon dioxide and water.

It has been observed that movements take place in the pigment granules of the retinal cells under the influence of light. The retinal cones also shorten in its presence and elongate in its absence. In the retinal rods of certain animals, notably frogs, there is a certain pigment called visual purple, which, though present in the dark, disappears in the presence of light, and reappears again directly the light is withdrawn. The visual purple is also found to undergo distinct changes of colour when exposed to other lights than white light.

It was on observations such as these that Hering based his theory of colour vision, consisting of six primary colour sensations, in opposition to the Young-Helmholtz theory of three only. The former suggests that these consist of three pairs of antagonistic or complimental colour sensations, black and white, red and green, yellow and blue, and that the stimulus producing each severally is caused by changes either of disintegration or assimilation taking place in certain three substances of the nature of visual purple, which it is assumed exists in the retina. Thus, in the case of the red-green substance, if assimilation is in excess of disintegration the sensation is red, if the reverse it is green, but when equal no sensation occurs. The Young-Helmholtz theory, on the other hand, teaches that there are only three primary elementary colour sensations—red, green, violet—and that the end-organs of the optic nerve in the retina, the rods and cones, consist of three varieties, each one specialised to respond to one of these three colour sensations, and that all the different shades of colour are due to the different degrees in which they are severally excited, the sensation of white being produced only when they are equally stimulated. This latter is the more generally accepted theory of colour vision. How these three colours, red, green, and violet, were selected and found to be the only fundamental colour sensations would take up too much space to describe here. It must suffice to say that it was due to a series of experiments by which the retina was exhausted for various colours, with the result that the fatigue manifested itself in these three colours, and it was found also that these three colour sensations could not be produced by any combination of other colour sensations.

The eye is not only a complicated optical instrument, but it is at the same time a vital organ of extreme delicacy functioned for the purpose of receiving sensory impressions of radiant energy, the velocity of whose radiations lie between certain definite limits, and transmitting them to the optic nerve centres in such a way that they can be translated into sensations of light and colour. It is owing to this fact that these rays have received the name of luminiferous ether. When the ether vibrations have acquired a velocity of 450 millions of millions a second they affect the retina and become appreciated as the sense of red; as the vibrations increase in velocity the colour sensations experienced are those of the solar spectrum from left to right, namely, from red through orange, yellow, green, blue, purple to violet, at which point the ether vibrations have reached the enormous velocity of 727 millions of millions per second. Beyond this point, what is technically called the ultra-violet portion of the spectrum is reached, where the vibrations become too rapid to be appreciated by the eye, and they consequently cease to be luminous. For example, "When a wire is heated in a spirit lamp placed in a dark room the particles of which the wire is composed are thrown into a state of violent vibration. As the heat increases the vibrations increase in rapidity. They are communicated to the ether, which surrounds and permeates everything; and the movements thus set up—infinitely small waves in this infinitely big ocean which fills all space—are sent off on their journey in all directions. At first the undulations are too slow to affect the retina, though they affect the skin. We perceive that the wire is hot if we hold it to our cheek an inch or two away, but our eye reveals no change. As the heat increases the rate of the waves increases, and when they reach to the enormous number of about 450 billions—that is, 450 millions of millions—per second, we see that the wire is glowing red. The ordinary physical cause of sight, then, is found in the fact that undulations or vibrations of almost inconceivable rapidity are affecting an organ specially adapted for receiving them, viz., the retina. . . . If we think this over we shall see that it involves the conclusion that what we call light does not exist in the universe apart from eyes to see it. The 'light rays' that physical science deals with are, in themselves, no more red or blue than the dark heat rays or than the X-rays of which we have heard so much of late; the sunshine would have no splendour, but from the eyes which see it. If eyes did not exist, the sun's rays would produce their beneficient effects on plants and animals just as they do now, but the splendour and beauty would not exist. They are due, not to the physical cause, but to the mysteries of a piece of living tissue, the retina, which has been given the power to select those rays composed of undulations of a certain degree of rapidity, and to somehow make them the occasion of mental facts of unspeakable beauty."—(Ryland. "The Story of Thought and Feeling.")

XUM

Having examined the nature of light and vision thus far, the question which naturally suggests itself is, how is the energy of light converted into a nerve impulse, and if, as seems probable, there are only three primary colour sensations, by what means are these severally differentiated?

The retina consists of several distinct layers of living protoplasmic cells, the most remarkable of which are the layer of rods and cones, which are found on the surface, and which, consequently, are the first to receive the impressions of incident rays of luminiferous ether. What happens in these cells under its influence? We know by examination of other tissues that protoplasm has the power of forming in its life processes certain bodies called ferments, which, under certain conditions and in the presence of favourable surroundings, produce chemical changes, either katabolic (destructive) or anabolic (constructive), without themselves being in any way affected. For instance, the gastric cells produce a ferment called pepsin, which is able to convert the proteids of food into peptones; so also the pancreatic cells possess a ferment called amylopsin, which is able to convert starches into sugar, with the evolution of various forms of energy, chemical, nervous, &c. Is it not possible, too, in case of the retinal cells, that the process by which the energy of light is converted into nervous energy may be a process of fermentation, and that the ions of luminiferous ether, acting on the ions set free by a ferment body present in these protoplasmic cells, may produce katabolic, and possibly anabolic, changes, which, liberating electro-vital force and nerve stimulation, are conducted by the piliments of the optic nerve to the visual centres in the brain, to be there interpreted by the consciousness as sensations of light and colour?

That light will produce these changes in the retinal cells is well illustrated by Waller's researches, and that the presence of ferment bodies in protoplasmic cells may, through ionic action, give rise to nerve force is supported by Dr. Allchin in a lecture given by him on "Nutrition and Malnutrition," reported in the *Clinical Journal*, April, 1905.

The former experiments are described in Halliburton's "Handbook of Physiology" as follows:—"The excised eyeball of a frog is led off by non-polarisable electrodes to a galvanometer. One electrode is placed on the front, the other on the back of the eye. A current of rest (demarcation current) is observed passing through the eyeball from front to back. When light falls on the eye this current is increased; on shutting off the light there is a momentary further increase, and then the current slowly returns back to its previous condition. Waller explains this by supposing that anabolic changes in the eye predominate during stimulation by light. With the onset of darkness, the katabolic changes cease at once, and the anabolic more slowly; hence a further positive variation. If the eyeball has been excised the day before the observations are made, or has been fatigued or injured, light produces principally katabolic changes, as evidenced by a negative variation. A slight positive effect follows when the light is shut off."

On the question of ferment bodies producing nerve energy, &c., Dr. Allchin expresses himself as follows:—"The vital activities of the living cells would seem to consist essentially in the formation of ferment bodies which alone, or in combination, effect those integrations and disintegrations which liberate chemical energy, and that this by transformation produces muscular work, nerve force, and secretory function, the fundamental manifestations of life. That these enzymes do bring about these changes in such conditions of temperature and alkalinity or acidity as obtain in the body appears to be certain, and as an explanation of the activity of the bioplasm, which elaborates these bodies, there is postulated an ionic action on the part of the cell contents, and their surrounding medium whereby charges of electricity of variable strength and character are brought into conflict, and that from the play of ions the manifestations of vitality result." Whether visual purple is of the nature of a ferment, as seems to be suggested by Hering's theory of colour vision, is not at present known, neither has its presence been demonstrated in the human retina as far as I am aware.

That ionic action should be produced by light in the presence of a ferment contained in the retinal cells would not be incompatible with the Young-Helmholtz theory of colour vision depending on three primary colour sensations, red, green, and violet, if we suppose that there are present in these cells three ferments capable of specially responding to each of these radiations (or one ferment even having the property of three separate reactions in an ascending scale of katabolism). It is important to note the position in the spectrum of these three radiations. On the extreme left are those which give rise to the sensation-red, of comparative long wave-length; that is, those which act least powerfully on the photographic plate; in other words, whose actinic or disintegrating powers are least powerful of the luminiferous rays; in the middle are those which give rise to the sensation of green, where actinic action occupies an intermediate position; whilst at the extreme right are those of shortest wave-length, which give rise to the sensation of violet. These are the so-called "actinic waves," whose actinic action is greatest, and which act most powerfully on the photographic plate.

Therefore, granting that in accordance with the Young-Helmholtz theory there are in the retina rods and cones which answer to each of these three primary colour sensations, and bearing in mind the above facts that the radiations producing them respectively occupy three fixed points in the spectrum, left, middle, and right, in an ascending scale of actinism (power to produce chemical change), I would suggest that an ionic action is induced by these radiations in association with three distinct ferments present severally in the rods and cones specialised to receive them, each ferment being specially capable of producing katabolic changes under the influence of the particular radiation concerned, and out of the energy thus liberated three corresponding degrees of nerve stimulation arise to affect the nerve cells in the deepest layer of the retina, which, on being transmitted by the nerve fibres to the nerve cells in the visual centres of the brain, are interpreted by the consciousness as the above colour sensations. The various other shades and colour effects seen in Nature are probably due, as the Young-Helmholtz theory teaches, to the different degrees of stimulation these three-colour terminals receive. Thus, if a large number of rods or cones, responding to the radiations to the extreme left of the spectrum, are brought under the influence of these rays, and those which respond to green and violet are hardly affected by their corresponding radiations, the sensation would be red. If, however, orange is the colour sensation produced, then it will be owing to the red terminals or rods and cones corresponding to red that are considerably influenced, the green rather more, and the violet only slightly so, &c. In bringing this paper to a close I must acknowledge my indebtedness to Watson's "Text-book of Physics," Ganot's "Popular Natural Philosophy," and Halliburton's "Handbook of Physiology."

XUM

Some Notes on the Giant's Causeway.

By EDWARD A. MARTIN, F.G.S.

THE wonders of the Giant's Causeway had drawn visitors to the Antrim coast long ere its geological importance was realised, and it may safely be said, even now, that not one in a hundred who visit it have any thoughts beyond those of mere curiosity, or consider for a moment how it came into existence, and what it all means.

Whitehurst, in 1786, was one of the earliest to understand the significance of its basaltic pillars, and his idea is still the accepted one, viz., that the rocks are the results of out-flows of lava from some volcanic centre or centres now hidden beneath the sea.

The Causeway proper is, of course, that portion which extends northward from the basaltic cliffs in the shape of a promontory towards the sea, beneath which it loses itself. But to the geologist, the whole of the five or six small bays to the east of it are full of interest, in consequence of the changes in the structure of the rocks, and the fact that regular columns of some kind or other are found throughout the whole, whilst the scenery to which they successively give rise is sufficient to attract numberless persons to whom geological facts are still as a sealed book.

The chief attraction in the Causeway is the large number of regular angular columns into which the lava has broken up. I use the words "broken up," advisedly, since there is no reason to believe that crystallisation has had anything to do with the formation of the columns. They have simply broken apart from one another, owing to the basalt, of which they

Fig. 1.—The divisions between these columns are very clear and open.

are composed, requiring less room, so to speak, when cold, than it did when it was a melted mass.

As one walks or climbs over the heads of some of the columns, one cannot help asking oneself how far below they extend. If one looks at others which have been exposed in the cliffs, one can count safely on a length of about 20 feet, below which they probably would be found to close in upon one another and form a homogeneous mass of basalt, cracked and jointed irregularly, perhaps, but showing no columnar structure at all. The whole thickness of the lower basalts has been estimated as about 60 feet.

As we see the Causeway dipping beneath the sea, we shall realise the possibility of the basaltic flow following on, hidden from our view, until it joins that which appears in the Isle of Mull, off the west coast of Scotland. Professor Judd has stated that the Mull volcano must have been 14,500 feet high. A lava flow from such a volcano would be no small affair, and a historic parallel may be found in the flow in Iceland, in 1783, when it extended for 50 miles.

When lava is in a fairly viscid condition, the mass may contract on cooling without fracturing, but when

Fig. 2.—Tops of columns showing tilt to the west.

it is approaching more nearly to a solid condition, it cannot, as a whole, continue to contract. It must break up into smaller masses. When what has been called its "breaking strain" has been reached, the rock will exhibit a series of layers of increasing temperatures in a downward direction. In this way the surface and that immediately underlying will exhibit a "platy" structure, but below where this appearance is exhibited, there will be a region of lava, whence the heat is but slowly being conveyed away, owing to its bad powers of conductivity. Then a new set of strains appear. There must be contraction, and some part must give way and be fractured. The tension becomes greatest in a lateral direction, and fractures appear, reaching down perpendicularly to the direction in which the lava flowed. It is difficult, if not impossible, to say what conditions are necessary for the fractures to appear so regularly as they have in the case of the Causeway, or why, in other cases close by, irregular blocks with but a starch-like columnar structure only should appear. When the columns are regular, they are generally hexagonal, and often the sides are remarkably equal in length. Why the hexagon should be by far the commonest form has been a matter of much discussion. Professor Bonney states in this respect, that Mr. Mallet has shown that "there are only three regular forms into which plane space can be divided, viz., equilateral triangles, squares, and hexagons, and the amount of work which has to be done in producing these is given approximately by the ratio, 100 : 68 : 52. So the last of the three requires the least expenditure of force." It is stated with probable truth that 99 per cent. of the columns in the Causeway are hexagonal, and that only one triangular column is to be found there.

Although in certain groups the sides of the columns

are fairly equal in size, there are many in which they are far from being so, whilst in many, one side may measure twice the size of the smallest side. They vary from about 8 inches to as much as a foot and a half. One of the unexplained phenomena in connection with the pillars is that the horizontal joints which divide them up into lengths of from 6 inches to two or three feet, do not always present strictly a plane surface, but the two portions fit into one another by either a con-

Fig. 3.—Irregular columns resting on shapeless basalt with red bole beneath.

cavity below and a convexity above, or *vice versâ*. Where the former has been the case, and the upper column has been removed, small pools of water collect in the concave top of the column.

Where the Causeway proper approaches the cliffs,

Fig. 4.—Rectangular and hexagonal columns. Note convex surface of hexagonal column in left hand bottom corner.

and the vertical sides of the columns show themselves *en masse*, the weathering of the joints is very noticeable, so that the sharp angles are lost and the different portions of the columns have acquired a rounded aspect, and have begun to assume a bomb-like appearance. This is particularly noticeable on the spot whence the illustration (Fig. 6) is taken, situated at the east end of the sixth of the little bays which collectively go to make up the Giant's Causeway, in the broadest use of the term. These are not, however, true volcanic bombs, but are merely harder, rounded blocks, from which the matrix in which they were wrapped has decayed.

The rocks which form the whole of the cliffs are divided into two principal lava-flows, and these are known respectively as the Upper and Lower Basalts. Between the periods represented by these two great flows, sufficient time elapsed to allow of great changes taking place in the upper portion of the earlier flows. This has resulted in the appearance of a great thickness of "red bole," a hydrous silicate of alumina, although thinner bands of the same rock occur between the successive minor flows, which go to make both the Upper and Lower Basalts. The illustrations (Figs. 3 and 5) show the lower ends of columns of rather irregular structure, which must have formed deep down in the upper lava flow. They rest upon the broken basalts, in which the fractures took no regular structure, and this in turn rests upon the thick red bole between the two chief flows. Westward from this, the base of the Upper Basalt descends to below sea-level.

One little promontory which juts out and so divides off the areas of two little bays appears to have resulted

Fig. 5.—Bomb-like concretions in basalt.

from having a backbone of harder igneous rock than the rest, and this must have flowed through a crater, or "neck," as we should now call it, that had opened out in a fracture in both the Upper and the Lower Basalts. This, indeed, may have been one of the fissures which fed the supply for the later of the Upper Basalts. How far back into the land away from the coast this neck extends has not been determined, but many of the fissures, in other places, through which lava has poured extend for many miles. Such a one is the great Cleveland Dyke, extending across the surface of Yorkshire. They are plentiful in south-west Scotland, and those who know the Biological Station at Millport, Greater Cumbrae, will recognise in the "Lion Rock" one such dyke, and in the great wall on one side of the Station grounds another. The latter can be traced into the cliffs at the back, and under foot, down to the shore in front. It is only about 3 feet wide, but has stood atmospheric denudation to a much greater extent than the Old Red Sandstone rock, into whose fissures the lava welled up.

Not the least interesting phenomenon in connection with volcanic dykes is the manner in which they have affected the strata which they have pierced, and the

effect on the strata may be regarded as a criterion as to whether the infilling of a fissure is actually a dyke or no. On the road between Portrush and Port Ballintrae, near Dunluce Castle, one passes what must at one time have been a great crack in the chalk, and this is filled with volcanic materials. But one looks in vain for any signs of metamorphism of the chalk, other than that which occurs throughout the district, and it is doubtful whether this is anything but an agglomerate, that is, a filling-in of volcanic materials, probably brought into the fissure from above. As a rule chalk and other

Fig. 6.—Weathered bomb-like concretions in the cliffs.

limestones have been changed for some few inches on each side of a dyke into a marble, often highly crystalline. Sir Archibald Geikie mentions such a case as occurring in Templepatrick Quarry, Antrim, where for some six inches on each side of the igneous rock the chalk has assumed a finely saccharoid condition, whilst its organisms have been effaced. Within a foot of the dyke the chalk has assumed its usual character, and the

Fig. 7.—Columns at top of cliffs. Between the two central masses was a later volcanic vent.

microscopic organisms of the chalk are again discoverable. All who know the chalk cliffs of the Antrim coast, such as those, for instance, which occur at the picturesque but neglected little fishermen's port of Ballintoy, where there is the maximum thickness of about 250 feet of chalk, will remember the indurated rocky character of the chalk, but this occurs far away from any lava-filled fissures. It is usual to attribute this induration to the baking process caused on the out-pouring of the lower basalts over the plateau. If this be the direct result of the operation it seems strange that the included fossils remain so apparent as they do; whilst seeing that the contact metamorphism of the chalk extends for but a few inches on each side of a dyke, it is difficult to see in those great thicknesses of indurated chalk beneath the basalt the direct effects of the heat given out from the lava. It was suggested some years ago by Mr. E. R. Sawer that chemical action resulting from the percolation of thermal waters may have played a considerable part in this induration of the chalk where unaffected by dykes, and there is much to be said in support of his contention. It is pointed out that in the Caucasus, the chalk, although it is covered by great sheets of andesitic lavas, still retains its usual friable character, whilst on the other hand, in the Crimea, indurated chalk occurs similar to that at Antrim, but without any signs of having been affected by igneous rocks. Possib , by the way, in the suggestion of hydrothermal action we may see the origin of what is known in the south of England as the "chalk rock," on the *Holaster planus* zone of the chalk.

Sandstones, when pierced by igneous matter, have been changed into a kind of quartzite, and this has

Fig. 8.—Basalt rocks off the coast showing dip to the west.

even assumed a columnar structure. A similar structure has sometimes been taken by clay and shale in similar circumstances, instances occurring at Strath, in Skye, and in Derbyshire, at Tideswell Dale. Geikie mentions that in the Ayrshire coal-field, a mass of intrusive basalt has resulted in the coal in contact with it being changed into a finely columnar coke. But in all cases the actual distance to which metamorphism has taken place is to be measured in inches only, and contact metamorphism requires a supplementary agency where the effect is found over large areas.

Sectional Ruled Paper Pads.—Messrs. W. and A. K. Johnston, Ltd., have sent us some pads of sectional paper, such as can be used for plotting mathematical curves, as well as for astronomical and other scientific purposes. The sheets are of two sizes, 8½ inches by 10½ inches; and 5¼ inches by 8¼ inches, and are ruled either in millimetres or in inches, and fractions of an inch.

XUM

TO OUR READERS.

The "Knowledge" Book Club.

WE would beg to call the attention of all regular readers of this journal to our new scheme of instituting a library of scientific works for the use of subscribers. This should, we believe, supply a long-felt want. Those interested in scientific pursuits are frequently handicapped by not being able to get hold of the particular book that they want, either because they have a difficulty in finding out what is the most suitable work for their purpose without seeing it, but more especially because, when found, that work often proves to be one of considerable expense, and hardly worth buying if only required to look up some special detail. Moreover, when working up a scientific subject, it is usually not only desirable to read some one work, but many different authorities should be consulted in order to get at what has been done in that subject. It would, as a rule, be quite out of the question to buy all these books; to merely dip into them when found in some public library is unsatisfactory; and technical books are seldom to be got in an ordinary lending library. But when a good catalogue can be consulted, a list of the required books made out and sent to the office, and the actual books forwarded at once to the home of the reader, to be retained any reasonable time, and then exchanged for others as often as desired, then one gets what may be called the acme of literary comfort. Even though one may have the use of other libraries it is just as well to belong to this (at so little extra cost), as, if the desired book is not procurable at one library, it may be in the other. In forming this library it is our intention to supply *any* book, regardless of price or date. This may be a difficulty, especially at the start, many works being scarce and not easy to procure at short notice, but we have already been purchasing a number of the older and standard works, and hope before long to have a very complete collection.

We feel sure that the majority of our readers will appreciate this institution, but they can, of course, hardly expect that the profit to be got out of a small sixpenny paper can be sufficient to start and maintain a good library, especially considering the uncertainty of the number of subscribers. We therefore propose to charge an entrance fee of ten shillings to cover the expenses of registration and of arranging the library and compiling the catalogue (which will be supplied free to subscribers). Extra volumes can be had at a reduced rate. Beyond this there will be no charge above the ordinary subscription rate. This, it must be recognised, is but a moderate charge, seeing that the total subscription to be paid, including the entrance fee and supply of the journal, is far less than what is charged at ordinary lending libraries, and but a fraction of the subscription which includes the delivery of a daily paper. We do not expect to clear any profit by this means, but hope to considerably increase our circulation, and so reap profits in other directions. Subscribers will, therefore, get the greatest benefits from this arrangement, and provided that a good proportion of our present readers join, and that we get a reasonable support from outside, we can guarantee that the book club will prove of great assistance to them.

But it will readily be comprehended that to make this book club a real success, not only from our point of view, but from that of the reader, a large number of subscribers is necessary. To make this clearer, let us suppose that each subscription enables us to get one book. Then, if one hundred readers joined, we should be able to provide a hundred books. This would give but a very limited choice. If a thousand joined we could have every scientific work published during the last few years. But if five thousand sent their subscription we could supply, on the average, five copies of each of such works, or, since many of the older books would not be much sought after, perhaps one hundred copies of a few popular ones. Then all subscribers would be sure of getting a copy of the desired book at once. So we sincerely hope that all who see the benefits to be derived from this establishment will give it their support. Even those who have no immediate need for the use of the library may at any time find that they wish to use it, and as it involves no payment beyond the entrance fee, no extra expense need be incurred by joining now instead of later on.

Resulting from the notice published in last month's "KNOWLEDGE," several applicants, who obtain their journal through a bookseller, have written to know if it would be possible to join the book club. Seeing that, for the support of the library, we are relying almost entirely on the very small profit derived when copies are bought direct and not through the trade, this would be impossible without extra charge. We will, however, gladly oblige anyone who likes to add to his subscription the difference between the wholesale and the retail price.

As regards the *sale* of books, it is not the intention to found a book-shop and attempt to rival old-established businesses. At the same time, arrangements will be made so that a reader wishing to retain as his own any book he may have obtained from the library, can do so on payment of the ordinary value of the book.

Each month a catalogue of additions to the library will be published in "KNOWLEDGE," and this will add greatly to the usefulness of the club as compared to other libraries.

BRIGHTNESS.

- 1st Mag.
- 2nd ,,
- 3rd ,,
- 4th ,,
- 5th ,,
- 6th ,,
- Variable
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Corona, Bootes, Coma.

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Photography.

Pure and Applied.

By CHAPMAN JONES, F.I.C., F.C.S., &c.

Opacity Measuring Apparatus.—The *British Journal of Photography* (page 873), quotes from the *Revue des Sciences Photographiques*, the description of an "Opacity Comparator," by M. Monpillard, which is illustrated by M. Nachet. This instrument is so similar to my "Opacity Balance," that I described in 1899 (Journal of the Royal Photographic Society, xxiii., 99), that it may justly be regarded as a modification of it. In both an incandescent gas mantle is the source of light; two mirrors give two beams of light, so that the plate to be measured may be interposed in the path of one; these two beams impinge on opposite sides of a prism and so are reflected into the eye-piece for observation. So far as the instruments differ, I believe mine to be the more advantageous and less costly. But my main reason for referring to this matter is that M. Monpillard claims that his instrument will do what it cannot do. He makes the same mistake that has misled many investigators both in England and on the Continent, in neglecting the light that is scattered by the silver deposit in the negative, or at least neglecting an unknown part of it, while this scattered light forms a considerable and variable proportion of the light transmitted, variable even in the different densities of the same plate. The claim, therefore, that such an apparatus will give "the absolute value of the density," is quite in error. I have found that by neglecting this scattered light the "density" readings may be increased from twenty to forty per cent. or more, when measuring ordinary plates, and up to as much as three hundred per cent. if the deposit is bleached. The chief claim that I made for my opacity balance was that it serves to quickly and accurately compare the deposits of the same density on any one given plate.

M. Monpillard has adopted a pinhole aperture in his eye-piece, to avoid parallax when viewing the final reflecting prism, to compare the beams of light reflected into the eye-piece by its opposite sides. I tried modifications of this method, and although it is quite practicable, it is so difficult to keep the eye central while attending to the matching of the two beams, that I substituted a small plaster plug on the surface of which the two beams fall side by side and in actual contact. This method entirely gets rid of the difficulty, and serves for all the opacities generally met with, when using an incandescent gas mantle. The direct observation method is available, if required for very high densities, by merely withdrawing the plaster plug and putting in an eye-piece. M. Monpillard's apparatus will give an aperture 3 m.m. wide for the measurement of spectra, but I regularly use an aperture of one millimetre and can easily reduce this to one half the width or less if desired. I cannot see, therefore, that M. Monpillard has modified my instrument in any way to advantage.

Depth of Field in Lenses.—In the photography of solid objects it is obviously necessary to get sufficiently good definition, at the same time and on a flat plate, of objects at different distances from the lens. Theoretically, perfect definition in the same plane of objects at different distances is impossible, but as no lens is theoretically perfect, so that a point in the object always gives an image of measurable size, and which is greater when the object is not at the exact distance focussed for, this becomes a purely practical matter. It is first necessary to determine the extent of surface that the image of an absolute point may be allowed to cover. Of course, this must vary, and vary largely, according to circumstances, but for purposes of calculation, a disc the one-hundredth of an inch in diameter is the accepted standard in this country, and a disc one-tenth of a millimetre (or the two-hundredth-and-fiftieth of an inch) is the Continental standard. For small work the English standard is too large, while the other is often too difficult to realise, and unnecessarily small for work even of moderate size.

The hyperfocal distance is a constant that is of much use in this connection, and may be described in various terms. If a lens is focussed on an object that is so far away that the image produced by the lens is not a measurable distance from the principal focal plane of the lens, the hyperfocal distance is the distance from the lens of the nearest object that the lens will define without exceeding the adopted standard. Then objects between the hyperfocal distance and infinity are defined without transgressing the standard of definition. If, instead of focussing on a very distant object, the hyperfocal distance itself is focussed on, then the distant object will be just well enough defined, and there will be also a considerable range of distance nearer the lens than the hyperfocal distance which will also be defined within the accepted standard. For practical purposes this nearer limit may be considered as half the hyperfocal distance. If, for example, the hyperfocal distance is thirty feet and the lens is focussed on an object thirty feet away, all objects from about fifteen feet to the horizon (or infinity) will be defined within the standard.

Methods of Calculating the Hyperfocal Distance.—The hyperfocal distance is directly proportional to the focal length of the lens and the diameter of its aperture, and inversely proportional to the diameter of the permissible disc of confusion. The usual formula for calculating it is therefore $H = \frac{f\,d}{e}$, where H is the hyperfocal distance, f the focal length of the lens, d the diameter of its aperture, and e the diameter of the maximum permissible disc of confusion. If the aperture is expressed in the usual way as a fraction of the focal length ($f/8$, &c.), representing the denominator of the aperture fraction as a, the formula becomes $H = \frac{f^2\,e}{a}$. If the focal length is measured in inches, and the disc of permissible confusion is taken at one-hundredth of an inch, then for the hyperfocal distance in feet, $H = \frac{f^2\,100}{12\,a}$. Dr. Lindsay Johnson has recently pointed out, and it has been pointed out before, that for an aperture of $f/8$, the denominator is so nearly 100, that, for this aperture and disc of confusion, the error is negligibly small if the formula is written $H = f^2$. That is, the square of the focal length in inches is the hyperfocal distance in feet. The effect of changing the aperture is easily calculated, the hyperfocal distance being directly proportional to the aperture diameter. (At $f/16$ it will be the half of what it is at $f/8$, at $f/32$ a quarter, and so on.) Dr. Lindsay Johnson also points out that the hyperfocal distance may be calculated exactly in Continental units, the diameter of the disc of confusion being taken as one-tenth of a millimetre, by multiplying the focal length in centimetres by the diameter of the aperture in centimetres, the resulting figure being the hyperfocal distance in metres.

Such figures, like almost all other figures connected with lenses, are not of the absolute value that they

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might be supposed to be from the way in which they are often referred to. They assume that the lens is free from every aberration, and even then do not include the effect of the obliquity of the rays that fall upon the plate everywhere except centrally opposite the lens. They are serviceable for all good lenses in the middle of the field, and so far as the field is flat and the defining power of the lens does not fall off. With the larger apertures of a "rapid rectilinear" lens, this will be a very small area of the plate that it is supposed to cover; with a modern anastigmat it will be of greater extent, but lenses of both classes vary very much in quality.

CORRESPONDENCE.

A System of Applied Optics.

To the Editors of "KNOWLEDGE & SCIENTIFIC NEWS."

DEAR SIRS,—While feeling highly gratified by the kindly and appreciative review of the above work which appeared in your November number, I would like to point out that I do not introduce an altogether new convention as to signs, as your reviewer implies. In fact, I have always arranged my conventions in entire accordance with those adopted by Coddington, in 1829, in his own work, and which have always struck me as the most practically reasonable sign conventions that have yet been put forward among the various writers on optics, all other methods being too abstract and academical.

Yours, etc.,
H. DENNIS TAYLOR.

York, November 16, 1906.

N Rays.

To the Editors of "KNOWLEDGE & SCIENTIFIC NEWS."

DEAR SIRS,—I should be obliged if you could tell me whether any investigators other than M. Blondlot, have obtained indications of the supposed N radiation. What do physicists in general think with regard to Blondlot's results, and his belief in his discovery?

P. M. RYVES.

Zaragoza.
October 19, 1906.

[Results partly subjective; in so far as they are objective probably N rays are long heat-waves. General attitude sceptical.—A.W.P.].

A Curious Optical Effect.

To the Editors of "KNOWLEDGE & SCIENTIFIC NEWS."

Dear Sirs,—The explanation of the above-mentioned by "B," in your last issue, is, I take it, comparatively simple and would constitute a good "Exam." question for students in optics and sight testing. The clear perception of a line at any angle depends on the relative curvature of the various meridians of the eye. Generally, the cornea of the eye has less curvature in the horizontal than the vertical meridian, and, as a consequence, the diffusion patches which form the total image of a line overlap on themselves in the horizontal meridian, with the result that the margins of the line remain clear and distinct, whilst those in the meridian at right angles overlap the margins, causing them to be indistinct. If the diagram is looked at with the page held horizontally, a reverse effect will be obtained. It is, perhaps, unnecessary to say that this defect is known as astigmatism, and that Sir G. Airy was one of the first persons to notice this defect of the eye, being astigmatic himself.

Yours truly,

W. BANKS.

Bolton.

ASTRONOMICAL.

By CHARLES P. BUTLER, A.R.C.Sc. (Lond.), F.R.P.S.

Physical Investigations of Sun Spot Spectra.

MESSRS. HALE, ADAMS, AND GALE have recently published the results of a long investigation on the causes determining the chief phenomena of sun-spot spectra, giving comparisons with similar variations of the spectra of terrestrial substances treated in different ways in the laboratory. One of the chief experiments consisted in volatilising the elements most important in sun-spot spectra under two or more degrees of temperature, produced by electric arcs of 30 and 2 ampères respectively, and by the electric spark. Tables are given of the lines of Titanium, Vanadium, Iron, Chromium, and Manganese, extending from the ultra-violet to λ 5800, showing their varying intensities when subjected to these different heat sources. The main results show that over ninety per cent. of the lines, which are strengthened in sun-spots, are found to be strengthened in passing from a 30-ampère arc to a 2-ampère arc. Also, of the lines weakened in sun-spots, over ninety per cent. are weakened or absent in the 2-ampère arc.

Over ninety per cent. of all the *enhanced*, or special spark-lines, are weakened or absent in the 2-ampère arc. From many collateral results it is generally considered that the temperature of an electric arc decreases with decreasing current strength, so that the above conclusions certainly point the suggestion that sun-spots are regions of lower temperature than the surrounding photosphere.—(*Astrophysical Journal*, xxiv., p. 185, October, 1906.)

Jupiter's Seventh Satellite.

The seventh satellite of Jupiter has been again observed by Professor Perrine, at the Lick Observatory. The co-ordinates of the observed position were :—

Position angle = 119°.1
Distance = 2578″
} 1906 September 25.9962 G.M.T.

Cape of Good Hope Observatory Report for 1905.

In his report on the work of the Cape Observatory during 1905, Sir David Gill gives special prominence to the progress made with the new transit circle. Some trouble has been experienced with the completion of the new underground azimuth marks, but the pits are now water-tight and the lenses mounted in position. Observations have been regularly made with the new system since October 31, 1905. For the adjustment of the marks in relation to the long focus collimating lenses, a new method was devised to get over the difficulty of bringing a spider web into coincidence with its own reflex image, and this is said to give an error of only $\pm$ 0.01″ for a single pointing. An important point brought out by this method of observation is the systematic diurnal variation of the azimuth of the transit circle between sunset and midnight. Although the discussion of the observations of circumpolar stars is not yet sufficiently advanced to determine the absolute variation of the azimuth marks, the opinion is expressed that they may prove sufficiently stable to determine the horizontal component of the Chandler change of latitude. The chief drawback is the frequent apparent unsteadiness of the marks, produced by irregularities of refraction in the intervening air, and it may ultimately be desirable to protect the intervening ground from the sun's rays.

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The new transit circle has been in regular use during 1905, all transits having been observed with the Repsold travelling wire, without clockwork, but an apparatus has now been supplied by means of which the wire is driven electrically across the field.

The new sidereal clock has now been provided with the air-tight enclosure, in which the air is kept uniformly about 75° F. by means of a thermostat; the temperature and pressure control are now regarded as perfect.

Publications.—The printing of the Cape Catalogue of 8,500 Astrographic Standard Stars has been completed, and the MS. of the Cape General Catalogue for 1900, including 4,300 Stars, has been passed for press.

Victoria Telescope.—The spectroscope has been under repair during a considerable period, and the telescope used for photography of star clusters, nebulæ, and the photographic observations of the satellites of Saturn and Uranus. Fifty-four negatives of stellar spectra have been measured and reduced for motion in the line of sight.

100-inch Mirror for Mount Wilson Observatory.

Just as the astronomical world is awaiting with special interest the account of the performance of the new 60-inch mirror made by Professor Ritchey, the munificence of Mr. J. D. Hooker, of Los Angeles, has enabled Professor Hale to arrange for the construction of a still larger reflector. This is to be 100 inches (2.54 m.) in diameter, and 13 inches (33 cm.) thick. The focal length is to be about 50 feet. The disc of glass will in all probability be furnished by the Plate Glass Company of St. Gobain, and the grinding and subsequent optical finishing will be done by Professor Ritchey at the Solar Observatory. The block of glass will weigh four and a-half tons, and it is estimated that the instrument may be completed in about four years. It is stated that the method of parabolising which Professor Ritchey has perfected quite eliminates the necessity of any hand work in obtaining the final figure. One of the chief difficulties anticipated is the disturbance caused by temperature changes, but as the instrument will be chiefly for use at night, means will be provided to keep the whole cool during the daytime by refrigerating machinery. Regarding the prospective working programme for this new leviathan, there are frequent calls for adequate spectroscopic study of stars beyond the reach, on account of their faintness, of existing instruments. Researches on the red stars, photography of small spiral nebulæ, minute study of the structure of the large nebulæ, investigations of stellar spectra with high dispersion, will all be greatly advanced by the facilities afforded by the greater light-gathering power.

Recent New Comets.

Comet g (1906).—This was announced by telegram from Kiel. The object was discovered at Copenhagen, on November 10, its position then being :—

	h.	m.	s.		d.	h.	s.
R.A. =	9	16	3·2	1906 November	10	17	3·5
Decl. = + 12°	28′	31″ (N).		(Copenhagen Mean Time).			

The daily movement in R.A. was given as 4.2m, and in Decl. +1° 10′, from which it will be seen that the comet was then travelling in a north-easterly direction.

A later telegram announced that the comet had been observed from Vienna on November 11, in the position :

	h.	m.	s.
R.A. =	9	20	9·5
Decl = + 13°	35′	25″ (N).	

From observations made November 10, 11, 12, and 13, various elements have been computed, a selection of which is given below.

ELEMENTS.

	Herr Ebell.	Prof. J. Franz.	Duncan & Williams.
T	1906, Dec. 7·8350	Dec. 15·168	Dec. 12·45
ω	354° 26′·6	34° 46′·8	31° 34′
Ω	82 7·1	86 34·9	86 26
i	46 12·2	71 48·7	69 52
log q.	0·07119	0·05560	q = 1·153

EPHEMERIS.

	R.A. h.	m.	s.	Decl.	
1906 Dec. 2	12	1	32	+ 46°	4′·2
6	12	56	27	+ 51	0·0
10	13	56	38	+ 53	52·8

Comet h (1906).—This was discovered by Metcalf, at Taunton, on November 14.

	h.	m.	s.		d.	h.	m.
R.A. =	4	4	6	November	14	10	0·4
Decl. = −2°	16′	(S).		(Taunton M.T.)			

It was observed later by Hammond (?) at Washington on November 16.

	h.	m.	s.		d.	h.	m.
R.A. =	4	4	11·45	November	16	11	38
Decl. = − 2°	46′	55″ (S).		(Washington Mean Time.)			

Motion, south-westerly. Position at discovery about half way between 35 and ξ Eridani.

BOTANICAL.

By G. MASSEE.

The Karroo Vegetation in August.

THE Karroo is a broad, elevated tract of country, situated in Cape Colony, which extends from the Ceres district on the west, to nearly as far as Grahamstown on the east. The altitude varies from about 1,800 to 3,000 feet. It is bounded on the north and south by mountain ranges. The rainfall is small throughout the area, in fact, in some parts a whole year may occasionally pass without rain; the daily range of temperature is very considerable. These marked climatic conditions are such that the vegetation is of a desert or semi-desert character.

A characteristic portion of this area, near the tiny village of Matjesfontein, about 200 miles distant from Cape Town, was investigated by Weiss and Yapp during the month of August. The plain, as far as the eye can reach, is covered with low bush or scrub. At a distance the scrub often appears to be continuous, but a nearer view shows it to be an open one, a considerable amount of bare ground being visible. The shrubs possess many features in common, having, for the most part a rounded outline, are richly branched, and usually possess inrolled, heath-like leaves. The prevailing colour is a dull greyish green. In the dry channels of water-courses, often not more than one inch deep and a foot broad, evidently formed by the rush of water during heavy rains, and also in certain low-lying patches where the rain had soaked into the ground, were observed patches of plants that were absent from neighbouring less-favoured and drier situations. Pretty little annuals occur under the shelter of larger bushes, etc., flowers and fruits being met with on seedlings only one or two inches in height, and on which the cotyledons are still fresh and green. The adaptation these ephemeral plants exhibit to a dry climate turns on the short duration of their lives, a single shower being sufficient to enable them to pass through the whole cycle of their development.

In comparison with other desert areas, succulent plants, along with bulbous or tuberous plants, form a very marked feature of the Karroo. Such plants, whether furnished with fleshy roots, tubers, bulbs, and other subterranean water-storage organs, spring up abundantly after the rains. Many of the Karroo plants, in common with those of other desert regions, are spiny. A noticeable feature was the spiral twisting of the leaves of many Liliaceæ and allied families. Sometimes each leaf is twisted independently, in other instances all the leaves are twisted or spirally coiled together. The majority of the flowers had a strong, sweet perfume. Probably the great majority of perennial plants,

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which are usually deep-rooted, depend largely on subterranean sources for their water supply. Other plants possess two distinct root-systems. One strong tap-root, which descends, and probably taps a subterranean water supply, while the other system consists of branches given off from the main root, and spread horizontally just under the soil. This last system probably collects water from slight showers, or from the heavy, nightly dews.

Lichens are most conspicuous amongst cryptogamic plants. A few ferns, mosses, and even liverworts, occur in shaded situations. The vegetation of the Karroo is represented by over 1,000 species, included in some eighty-four natural orders. The order Compositæ is the most conspicuous family, not only as regards numbers of species and of individuals, but also in the great variety of habit and adaptation to exceptional conditions.

Coloration of Wood by Fungi.

Independent of the discoloration of unpainted and sawn wood due to dirt, oxidation, etc., certain other stains of various colours are also often present, more especially on newly-sawn wood. The stains may be blue, brown, black, pink, purple, and yellow. These discolorations have been found to be due to fungi, by Hedgcock, who states that in the United States much injury is done to boards of pine, gum poplar, and other kinds. The blueing of the wood of the western yellow pine is caused by *Ceratostomella pilifera*; this blue stain of pine-wood has long been known in Europe, where it is caused by the same fungus.

The stain caused by species of *Ceratostomella*, *Graphium*, *Hormiscium*, and *Hormodendron*, is due to the dark-coloured mycelium permeating the substance of the wood; no stain exudes from the mycelium. In species of *Pemcillium*. The discoloration is due to a yellow or red stain from the mycelium, which is taken up by the wood. These stains fade when the wood dries, but reappear when it is moistened. This discoloration caused by *Fusarium* is partly due to the presence of a soluble stain secreted by the fungus, and taken up by the wood, and partly to the presence in the wood of coloured mycelium.

No mention is made of the brilliant verdegris green colour of wood of ash, oak, etc., caused by the equally brilliantly coloured cup-shaped fungus, called *Peziza æruginosa*, so common in this country, and from which various articles are made, and known as Tunbridge ware. Presumably this fungus is rare or absent from the United States.

Leaf Variation in Coprosma Baueri.

Some remarkable changes in form of the leaves of this common New Zealand shrub are recorded by Dr. Cockayne. When growing wild on wind-swept cliffs by the sea, where it may receive at times a certain amount of sea-spray, the leaves are fleshy, glossy green on the upper surface, much paler beneath, and the margins recurved. This latter character is sometimes carried to such an extent that each half of the blade is rolled round itself, or the one half may be rolled round the other, the leaf thus presenting the appearance of a cylinder. The size of such leaves varies to some extent, but an average is 3.2 cm. by 1.9 cm. As *Coprosma* is amendable to cultivation, it is commonly used for hedges, and when grown in fairly sheltered situations, away from the influence of the sea, the leaves are much larger, thinner, not quite so glossy as those of wild coastal plants, and quite flat. An average size of such leaves is 12.3 cm. by 9.7 cm. If the upper portion of a cultivated hedge happens to be exposed to wind, the leaves show a tendency to curl, the amount of curling being in proportion to the amount of exposure to wind.

New Ferns from New Zealand.

Two new ferns are described by Field, in *Trans. N. Zeal. Inst.* One, named *Doodia aucklandica*, is allied to *D. media*, from the same country, differing in having a more compact habit and other important features. The second is named *Pteris novæ zelandiæ*, most nearly resembling *P. tremula*. The author considers that cresting arises from plants growing under some peculiarly favourable conditions, as in several instances specimens become so under cultivation. When a plant breaks into cresting, seedlings from it are apt to exhibit the peculiarity in an exaggerated form.

CHEMICAL.

By C. AINSWORTH MITCHELL, B.A. (Oxon.), F.I.C.

The Bleaching of Flour.

NUMEROUS methods of bleaching flour have been devised (see "KNOWLEDGE & SCIENTIFIC NEWS," Vol. II., p. 86; Vol. III., p. 563), but according to the investigations of M. Fleurent the only processes that have any industrial value are those in which nitrogen peroxide is used as a reagent. Pure oxygen or ozone does not affect the colour, and although ozonised air has a bleaching effect, this is to be attributed solely to the nitrous vapour with which the gas is charged. Moreover, flour treated with ozone acquires a disagreeable odour, which destroys its commercial value. In the bleaching with nitrogen peroxide, the oil in the flour combines with the gas, and the weight is increased. This fact affords a means of detecting bleached flour in untreated flour, for on extracting the oil with petroleum spirit, and converting it into soap, the product has a brownish red colour if nitrogen peroxide had been used in the bleaching, whereas the soap solution from an unbleached flour is pale yellow. The intensity of the red colour is proportional to the amount of the nitrogen peroxide that has been absorbed by the oil; and M. Fleurent finds that the test is capable of detecting five per cent. of a bleached product in ordinary flour. The oil in bleached flour becomes acid less readily than in the case of ordinary flour, and it is in this sense only that the bleaching process can be said to have any "preservative action."

An African Arrow Poison.

Dr. Bolton has communicated to the Royal Society the results of his examination of a recently discovered arrow poison, obtained from Ghasi, a town in Northern Nigeria. Dr. Alexander, who forwarded the poison, states that in the fresh condition it is a semi-fluid, black, sticky substance, consisting of or containing the juice of a certain species of fig. It is smeared on sticks, and when required for re-dipping arrows is scraped off and heated. The poison received in London was spread on the ends of two canes, and dusted over with powder from the inside of a gourd. It was a soft, black paste, with a peculiar sweet smell. It dissolved readily in water, with the exception of a small portion consisting chiefly of starch granules. The solution filtered from the insoluble matter was transparent and dark brown, and had a slight acid reaction. The poison was not affected by boiling, and was thus not a true toxine. It acted upon the muscular tissue, and did not appear to have any effect upon the central or peripheral nervous system. Death results through the direct action of the poison upon the muscular system. So potent is the poison that Dr. Alexander reports that a native shot with a poisoned arrow was dead within 25 minutes. The chemical nature of the active principle has not yet been determined.

Protecting Iron with Paper.

A new and valuable use for paper has been discovered by Mr. L. H. Barker, in the course of experiments on the methods of protecting iron and steel structures against the action of moisture and atmospheric corrosion. When coats of various kinds of paint were found to be ineffective, trials were made to determine the protective power of paper impregnated with paraffin wax. The iron was first thoroughly cleansed from rust by means of wire brushes and a coating of sticky paint applied. The paper was then pressed tightly on to the surface of the fresh paint, with the edges made to overlap somewhat, and coats of paint at once applied to the surface of the paper. It was found that iron and steel thus protected remained in the same

condition as at first, after constant exposure for 27 months to the action of smoke, while the sticky layer of paint on the metal was also intact, and in some places still not dry. It was also proved that steel treated in this way could remain in contact with moist air and sewer gases without its surface being in any way attacked.

The Amount of Alcohol in Bread.

The fact that, in the process of leavening, flour is made to undergo a restricted fermentation, suggests the probability that the finished loaf may retain a small amount of alcohol which has not been expelled by the heat of the oven. This supposition was confirmed by Herr Balas, who found that freshly-baked English bread contained from 0.2 to 0.4 per cent. of absolute alcohol. His assertion has recently been investigated by Herr Pohl, who has distilled large quantities of two kinds of German wheat bread with water, and examined the distillates. In every instance he has detected alcohol, though in smaller quantities than those found by Herr Balas, the proportions ranging from 0.05 to 0.08 per cent. In addition to alcohol, the distillates also invariably contained a small amount of a dark brown oil with the distinctive odour of new bread.

The Occurrence of Copper in Olive Oil.

Signor Passerini has analysed 28 specimens of olive oil of different origin and finds that copper is present as a normal constituent, though only in the small proportion of about 0.005 parts in 1,000. Some of the olive trees had been treated with a one per cent. solution of copper sulphate, but this had not increased the quantity of copper in the oil expressed from the fruit of those trees. This minute trace of copper in the oil is obviously too insignificant to have importance from a hygienic point of view.

GEOLOGICAL.

By EDWARD A. MARTIN, F.G.S.

A Non-Volcanic Crater.

THE crater of Coon Butte, Arizona, is of a remarkable nature, in that it contains no volcanic rock whatever. This appears at first sight to be somewhat paradoxical, but the theory is now generally accepted that the crater was not formed by the extrusion of material from below, but was the result of the impact of an enormous meteorite falling with a tremendous velocity on to this portion of our globe. This is in variation of the theory which was advanced in 1896, by G. W. Gilbert, that the crater, although exhibiting no volcanic rock, is essentially volcanic, having been produced by an explosion of steam generated by some subterranean volcanic intrusion. This particular district in Arizona has long been remarkable for being the source of many thousands of masses of meteoric iron, and whenever meteors come to be spoken of, those of Arizona are always the first to be referred to. These masses weigh from a thousand pounds down to a few ounces. A detailed examination has been taking place, and this has revealed several thousand additional masses, adding about another ton to the ten tons and upwards already found. We can conceive of a gigantic meteorite weighing many scores of tons, travelling for ages as a small planet, and finally dashing earthwards. Then as it neared that part of the earth where was the American Continent, it suddenly exploded, sending fragments all around, and riddling the soil of the Canyon Diablo with thousands of missles, whilst the main mass struck the earth where now is found the Coon Butte. Besides iron, the meteorites have been found to contain large quantities of the magnetic oxide of iron, with nickel, iridium, and platinum. The crater is now being explored, and meteoric masses have been found therein at depths varying from 300 to 500 feet, with a large amount of minutely pulverised silica, and fragments of limestone, whilst volcanic rocks are conspicuous by their absence.

Intrusive Craters in the Moon.

The formation of a crater by intrusion instead of by extrusion is a phenomenon of extraordinary interest, and astronomers might well consider the possibility of the formation of some of the Moon's craters by a similar process. It has always seemed to me that there is a remarkable likeness in the form of lunar craters to the rising walls around a point in a liquid where a body has fallen in from without. The "splash of a drop" may, perhaps, give a clue to their formation, now that the theory of intrusion as the cause of the crater of Coon Butte has come to be so well established.

Pacific Depths.

In 1899 the United States steamer *Nero* was engaged in the survey of a route for the trans-Pacific cable. From a report which has now been issued, we find that several submarine mountain ranges were encountered, one, east of Guam, having peaks rising to a maximum of 689 fathoms below the sea-levels, whilst the valleys descended to depths of more than 5,000 fathoms. Four soundings below the 5,000-fathom line were made in the abyss now known as the "Nero Deep." The deepest, 5,269 fathoms, was about seventy-five miles east-south-east from the island of Guam, and is the deepest sounding ever recorded, being only sixty-six feet less than six statute miles.

Upper Carboniferous Rocks of West Devon.

The winter meetings of the Geological Society of London opened on November 7, with a paper by Mr. E. A. Newell-Arber, on "The Upper Carboniferous Rocks of West Devon and North Cornwall." The author had been at immense trouble to accurately survey the coast-sections south-west of Bideford, and the result was seen in his comprehensive paper. Special attention was given to two lithological types—(1) the Carbonaceous Rocks, which contain inconstant and impersistent beds of the impure, smutty coal, known locally as "culm"; these beds have yielded plant-remains; and (2) Calcareous Rocks, partly of marine and partly of freshwater origin, consisting of well-marked, impersistent bands of impure limestone, and conglomeratic beds of calcareous nodules embedded in shales. One of the limestone-bands, the Mouthmill Limestone, is marine, and contains an abundant fauna; while in others the only fossils are *Calamites suckowi* and *Alethopteris lonchitica*. The calcareous nodules, which are not ferruginous, occur in thin shale-beds, 2 to 3 feet thick; they commonly contain a marine fauna, with goniatites, lamellibranchs, and fish-remains. The conclusion was reached that the rocks belong to the Middle Coal-Measures, and that there is no evidence of Upper Coal-Measures.

Porphyritic Crystals in Granite.

I note in the *Quarry*, some illustrations by J. T. Rodda, of Eastbourne, of a cruciform twin-crystal of felspar in Cornish granite, a remarkably fine specimen, and of a porphyritic crystal of felspar in similar granite, showing zonal inclusions. It is remarked that there is a good deal of this coarsely crystalline granite, with conspicuous felspar crystals, in London buildings; and when polished these granites give an opportunity for very interesting mineralogical studies, not only with regard to twinning, but also with respect to the regular zonal inclusions of other minerals, which have often been built in the felspars, marking successive stages in the growth of the crystal.

ORNITHOLOGICAL.

By W. P. PYCRAFT, A.L.S., F.Z.S., M.B.O.U., &c.

The Black-Headed Gull.

THE Cumberland County Council have requested Messrs. Thorpe and Hope, of the Carlisle Museum, to prepare a report on the food of the black-headed gull (*Larus*

ridibundus), with a view to ascertaining if it is harmful to the fishing or farming industries. Accordingly, these gentlemen have issued a circular requesting answers to the following questions: (1) Do you consider the black-headed gull harmful to fishing or farming industries? State reasons. (2) Have you ever examined the gullet and stomach of this gull? If so, what were the contents? (3) What, in your opinion, is the staple food of this gull?

Under the circumstances, this method of obtaining information is about the only possible one, but it is, nevertheless, most unsatisfactory and unreliable. Of the few people who have ever examined the contents of the stomach of this gull, for example, how many took note thereof, and of these, how many were really qualified to analyse these contents accurately? And on this question the whole case for protection, or otherwise, rests.

This dallying with the question of protective or repressive measures in this matter is to be greatly deplored. It is a question for the Board of Agriculture, who should have appointed, long since, an expert, or experts, to study, impartially and exhaustively, the whole matter of the relation of our native birds to the industries. For years past this line of investigation has been prosecuted by a specially appointed Bureau in the United States, and the results they have achieved are of the highest importance and value.

It must not be forgotten that under the conditions existing to-day in this country any given species of bird may well exceed its proper limits; when exhausting its normal food supply, it may be obliged to tap others, and so become a nuisance. But it is not necessary that new supplies should be tapped; it may become no less a nuisance by drawing too largely on its legitimate food, where this brings it into competition with man, as in the case of fish-eating birds, for example. And in such cases it must certainly be kept in check.

But the "opinion" of the majority of the so-called observers of birds is absolutely worthless.

Greater Yellow Shank in Scilly.

At the first meeting of the winter session of the British Ornithologists' Club, an adult specimen of the greater yellow shank (*Totanus melanolencus*) was exhibited, which had been killed at Tresco, Scilly Islands, on September 16, by Captain Doreen Smith. This makes the first record of this species either in Great Britain or the Continent. The sex of the bird does not appear to have been determined.

Waxwing in Wales.

In the *Field* (November 17), it is recorded that a waxwing was seen on November 7, near Bala, in North Wales.

Hoopoe at Whitby.

On November 13, Messrs. Rowland, Ward and Co., of Piccadilly, received for preservation a male hoopoe, which had been shot on the moors near Whitby.

Little Owl in Hertford and Elsewhere.

Messrs. Rowland, Ward have also received a little owl, a female, shot at Bramfield, near Hertford, on October 26, and another, a male, shot near Newport, Essex. Another is recorded (*Field*, November 17) to have been seen in Derbyshire on November 5. Since imported examples of this species have been repeatedly set at liberty in this country, it becomes doubtful whether the birds here referred to are genuine wild birds or the progeny of the liberated captives.

PHYSICAL.

BY ALFRED W. PORTER, B.SC.

Haidinger's Interference Rings.

IN the *Philosophical Magazine* for November, Lord Rayleigh points out that Haidinger was fully acquainted with the character of his rings and especially the distinction between them and the rings named after Newton and dependent upon a variable thickness in the thin plate. The latter are of the same kind as the colours on a soap film, the variety of colour being due to a corresponding variety in the thickness of the film; the colours appear as though painted on the film. Haidinger's, on the other hand, are obtained with a perfectly parallel faced film, such as a thin sheet of mica or selenite, and are due to the different obliquities of the bundles of interfering rays. Contrary to the case of Newton's fringes, they are localised at infinity. The usual text-book formula for the retardation between the interfering rays is:

$$\text{Retardation} = 2\,\mu\, e \cos. r,$$

where μ is the refractive index of the film, e is its thickness, and r the angle the ray in the film makes with the normal. The retardation, and, therefore, the particular colour effect, varies with e, and this represents Newton's case. It also varies with r when e is constant, and this is Haidinger's case. Of course, all manners of intermediate effects are obtained when e and r both vary. Lord Rayleigh gives the following directions for best seeing Haidinger's rings by transmission:—"The transmitted rings are best seen by holding the mica close to the eye (focussed for infinity), and immediately in front of a piece of finely-ground glass behind which is placed a salted Bunsen flame." Plates about a fifth of a millimetre thick are suitable. We may point out that a very effective way of seeing them is to replace the ground glass by a lens (a pocket magnifier serves very well), held in front in such a position as to appear "full of light"; the mica, as before, being close to the eye. Those in possession of a mineralogical microscope can obtain the rings very perfectly by placing the mica on the stage and examining the back focus of the objective by means of the additional lens usually supplied for the purpose, which is inserted in the tube; the illumination, as before, must be monochromatic. Lord Rayleigh describes some novel effects. Mica is bi-refringent, and, in consequence, there are two sets of rings. These may nearly annul one another for certain thicknesses of mica. When this is the case, by employing a Nicol prism, which can be rotated, there are four positions for which the inner rings become distinct.

The rings formed on the same mode as Haidinger's are the ones which are employed in Michelson's, and in Fabry and Perot's Interferometers, for the absolute determination of the wave-lengths of light.

Haidinger's Tufts.

The name of Haidinger has also been prominently brought forward in another connection. In the *Proceedings* of the Royal Dublin Society, Professor W. F. Barrett discusses the tufts or brushes which are known by the above name. When a bright sky or any brightly illuminated surface is looked at through a Nicol prism, a pair of small, yellow cones, joined apex to apex, are seen in the direct line of vision. At right angles, and filling the larger space on each side of these cones, a faint blue or violet colour is seen. The yellow tufts resemble an hour-glass. Their longer axis rotates if the Nicol is rotated. If the Nicol is kept unmoved before the eye, the effect vanishes in a few seconds; if the Nicol be now suddenly turned it reappears and again fades. This is the origin of the difficulty which some people experience in seeing the tufts. To ensure their appearance, Professor Barrett recommends that the Nicol be turned backward and forward every few seconds, and a piece of cobalt blue glass be interposed.

When they have been found, they may still be seen even though the Nicol be removed. This is, no doubt, due to the partial polarisation of the light reflected from the white background. These brushes are closely associated with the yellow spot (or *fascicula lutea*), of the eye. That their detection is due to the retina is demonstrated by the following experiment: An opaque screen with two pin-hole apertures, each 1 mm. in diameter and 2 mm. apart, held between the eye and the Nicol prism, would give a double image of Haidinger's tufts if they were due alone to the refracting media of the eye; but only a single image is seen; hence their detection is due to the retina. The size of the region of the retina which is effective can be found by measuring the length of their projected image on a sheet of white paper, placed at a known distance from the

eye. Lines drawn from the extremities of this image through the second nodal point of the eye till they meet the retina mark out very nearly, indeed, the retinal area affected. This area is found to sensibly coincide with the area of the yellow spot, whose diameter is from 8 mm. to 1 mm. The *fovea centralis* is only .2 mm. diameter. Hence Brewster and Helmholtz were wrong in attributing this effect to the centre region alone. Throughout the yellow spot the retinal rods are absent, only cones being present; and it would seem as if a close connection existed between this peculiar retinal structure and the detection of polarised light and the plane of polarisation by the unaided eye.

Haidinger, a mineralogist, geologist, and physicist of considerable note, was born at Vienna in 1795, and died in 1871. In 1822 he took up his abode for a time in Edinburgh, after which he returned to Vienna. On the completion of the Geological Survey of the Austrian Dominions in 1862, he superintended the preparation of the maps which were issued.

Alpha Particles.

Professor Rutherford has completed an investigation along with Dr. O. Hahn which shows that, from whatever radio-active source alpha particles are obtained, their properties are identical. This statement applies not only to the particles from the various products of radium, but also to those from actinium and thorium. The observed value of the charge per unit mass comes out about 5,000. The corresponding value for hydrogen as measured in electrolysis is nearly 10,000. The hydrogen ion is supposed to be the hydrogen atom with a positive charge; so that (taking the mass of an atom of hydrogen as unity) the above number, 10,000, represents the positive charge on an atom of hydrogen. If the charge on an alpha particle is taken as being the same as that on an atom of hydrogen the mass of an alpha particle must be about 2. Now, there is very plausible evidence that the alpha particles either consist of, or are easily transformed into, helium atoms. But the mass of a helium atom on the same scale is 4. If the belief in the practical identity of the helium atom and alpha particle is adhered to it is necessary to suppose that the latter carries *twice* the positive charge on a hydrogen atom; or, in other words, carries the same charge as that on any divalent atoms, such as the copper in cupric salts.

ERRATUM.—In the Physical Notes for October, the focal length of a combination of two lenses should have been given as f_1f_2/K instead of f^2_1/K.

ZOOLOGICAL.

By R. LYDEKKER.

The Internal Ear of Mammals.

THE method of preparing the membranous labyrinth of the internal ear of mammals invented by Dr. Albert Gray has resulted in some important observations on the structure of this region in various mammals, which are recorded in a recent issue of the *Proceedings* of the Royal Society. From an examination of sixteen species, Dr. Gray has been enabled to state that there are differences in the form of the cochlea, in the size of the perilymphatic space of the semi-circular canals, and in the relative size of the otoliths. Apart from its altogether peculiar modification in the egg-laying group, the cochlea presents two main types; namely, a sharply pointed one, characteristic of carnivores and rodents, and a flattened one found in man, monkeys, lemurs, ungulates, and cetaceans. The seal is, however, an exception in this respect among the carnivora, the cochlea being boat-shaped rather than pointed; and among the ungulates the flattened form is least developed in the pig.

As regards the perilymphatic space of the semi-circular canals, this is relatively large in man, monkeys, and the seal, but in the other species examined it is either minute or wanting. Hitherto the otoliths have been assumed to be very small in all cases, but those of the porpoise, the seal, and the kangaroo have already been proved to be exceptions to the rule.

Popular Science Teaching.

In the *Museum Gazette* for October, occurs the following sentence:—"The ichthyosaurus was a four-footed reptile which had taken to the water and received modifications (loss of feet, etc.), just as the whale is a four-footed mammal which has taken to the water and lost its legs." Later on we read that: "In the manatee and dugong, all the digits are webbed together into a fin, but upon this fin rudimentary nails are produced. In explanation of this we must remember that the nails are modified parts of the skin, and are not formed in connection with the bones."

Should the writer of these passages read them again, we wonder whether he would feel wholly satisfied with the manner in which he has expressed himself. Again, we wonder whether, on reflection, he really believes another statement in the same issue to the effect that the tenrec of Madagascar and the European hedgehog inherit their propensity to slumber from a common ancestor.

New Antelopes.

Africa still continues to yield something new in the way of animals; this time in the shape of a couple of antelopes of more than ordinary interest, which have recently been described in the columns of the *Field*. The first of these is an eland, from British East Africa, of which the mounted head and the body-skin have been presented to the British Museum by Colonel Patterson, its discoverer. The presence of a white chevron on the forehead and certain other details of colouring distinguish this eland (*Taurotragus oryx pattersonianus*) from its kindred further south. Not much in this, the reader may say. As a matter of fact, it is of great importance (so far as it is justifiable to use that term in connection with natural history), since a similar chevron is found in the elands of the Bahr-el-Ghazal and Senegambia, which have been regarded as specifically distinct from the southern animals. Colonel Patterson's specimens suggest that all will prove to be local phases of a single species.

The second new species, based upon a mounted head, shot by Captain P. E. Vaughan, in the south-western district of the Bahr-el-Ghazal province of the Sudan, and presented by him to the British Museum, is a near relative of that handsome member of the waterbuck group from the White Nile and the Sobat known as the white-eared kob (*Cobus leucotis*). The old bucks of the latter are characterised by the ears and much of the jaw, as well as the chin, the throat, and under-parts being white, while the rest of the upper surface is deep blackish-brown. In the new species the general plan of colouring in the adult bucks is nearly similar; but the coloured area is foxy red in place of dark brown. *Cobus vaughani*, as the new species is called, is therefore a connecting link between the white-eared kob and the nearly uniform chestnut species found in Uganda and West Africa.

Crocodile Leather.

A correspondent in the trade, who is a reader of "KNOWLEDGE," has sent me two specimens of commercial crocodile leather, with the request that I would give a note upon them in this column. The one specimen is from Mexico, and the other from Florida. In the former, the place occupied by each scale is occupied by a small pore, situated near one end; while in the other such pores are either entirely wanting or are represented by mere traces in some of the spaces. My informant states that these characters are quite constant in Mexican and Florida skins respectively. Mr. G. A. Boulenger, of the British Museum, tells me that both specimens are from the leg, and that while the Mexican example is taken from the American crocodile (*Crocodilus americanus*), the Florida specimen is the product of the Mississippi alligator (*Alligator mississippiensis*). I am further informed that the pores are connected with sensory organs. Why they should be fully developed in the one species and practically obsolete in the other, remains to be explained.

XUM

REVIEWS OF BOOKS.

ASTRONOMY.

Stonehenge and other British Stone Monuments, Astronomically Considered, by Sir Norman Lockyer (Macmillan and Co., 1906, pp. xii. + 340; 10s. net).—Readers of Lockyer's "Dawn of Astronomy," in which an almost fabulous antiquity is claimed for certain Egyptian temples, will not be surprised at his having turned his attention nearer home to a similar investigation as to the possible dates of Stonehenge, the Hurlers, the Merry Maidens, and other prehistoric British monuments. Much of the material in the present volume will be familiar to readers of *Nature*, and some of the results have been published in the Proceedings of the Royal Society, but the new volume is a complete discussion of the subject. It is interesting to astronomers to see how many sciences have to own an obligation to astronomy for testing hypotheses, and for many other purposes, very often chronological. In the present instance it is archæology that shares the burden of investigation, but we cannot claim to *know* enough of admittedly prehistoric Britain to be able to do more than acquiesce in the possibility of some of the conclusions. The author's enthusiasm for his subject is apt to carry him to his desired conclusions across a morass of doubtful speculation where "path" is a euphemism for very uncertain stepping stones, on which few would be inclined to venture in search of an *unknown* goal. Once admit the goal and the "stepping stones" are highly ingenious, admirable artifices, but since the question is, after all, a problem and not a theorem, there should be something better than a lack of complete refutation on which to claim success for any solution. Among so many more or less plausible assumptions, possibly more than one, perhaps vital to the argument, might be overthrown, but *cui bono?* Sir Norman Lockyer has in any case produced an interesting book, with admirable descriptions and illustrations, and carefully collected legends on a subject the facts of which, so far as they go, are well worthy of study. Those to whom the "Dawn of Astronomy" brought conviction may accept the results of the present volume without difficulty. Others will be more sceptical, except, perhaps, Cornishmen, or those of Welsh descent, whose pride in the antiquity of their race will enable them to skim the doubtful places, imbued beforehand with the author's faith by their strong sympathy with his conclusions.

BOTANY.

A Text Book of Fungi, including Morphology, Physiology, Pathology, and Classification, by George Massee (London: Duckworth and Co.; 6s.).—This volume supplies a want which has for some time been felt, because of the fact, as stated in the preface, that "During recent years our knowledge of fungi, from morphological, biological, and physiological standpoints respectively, has increased by leaps and bounds," so that this increased knowledge has thrown the existing handbooks out of date, and students were waiting anxiously for a new guide. Inasmuch as a knowledge of the structure and life-history of fungi is now required of those who seek a degree or diploma in Agriculture and Forestry in Universities and Colleges, the issue of the present work is amply justified, and doubtless the right author has been selected for the work, and he gives an assurance that it is arranged as a text book for educational purposes, and is written on the lines required by the Board of Agriculture. Opening the volume, we are at once struck with the number of illustrations (140), which assist in elucidating the text. And again, by the useful bibliography which concludes each chapter, and indicates where further information can be obtained. After intimating that already no less, than 55,000 species of fungi have been described, good, bad, or indifferent, and included in *Saccardo's Sylloge*, with the intimation that probably not more than half of these are autonomic species, it is evident that a text-book of little more than 400 pages cannot by any means exhaust the subject; indeed, it is marvellous how much our author has contrived to condense within that compass, and yet include all the most prominent of the theories and demonstrations of recent times. Nearly half the book is occupied with the classification, which is possibly the least interesting, but not the least essential, although, naturally, the classification of 50,000 plants cannot be fully justified and elucidated within some 200 pages. All mycologists must welcome this volume, which, even the practised hand will find extremely useful, in keeping him up to date. It is, moreover, neatly "got up," of a handy size, and provided with a good index. We heartily commend Mr. Massee's latest literary effort, and can only hope that it will secure the success it so eminently deserves. M. C. C.

The Romance of Plant Life, by G. F. Scott Elliot, M.A. Seeley and Co.; 5s.).—The title to some extent disarms criticism, and we remain in uncertainty as to whether the romancing is done by the author or the plants he mentions. The information offered bears on all kinds and conditions of plants that exist at the present day, or ever did exist, described under such headings as "The Scythian Lamb," "Palæolithic Family," The Caustic Creeper," Ingenuity of Weeds," etc. The story relating to the evil-doings of the famous Upas tree is ruthlessly exposed and stated to be pure romance. Again, the celebrated Traveller's tree, which for all time has been credited with saving the lives of innumerable travellers in the desert, proves to be a myth. The tree has a considerable amount of water in a hollow at the base of its leaf, and it is possible to drink this water. Unfortunately, the tree only grows in the vicinity of swamps or springs, and the water, which the author tasted, out of curiosity, "had an unpleasant vegetable taste, with reminiscences of bygone animal life." Probably the book under consideration is altogether unique in the amount of accurate information, bearing on every phase of plant life as seen in a state of nature, as also on the influence exercised by plants on other forms of life. There are numerous very beautiful whole-page illustrations, and the binding also is quite artistic.

CHEMISTRY.

The Chemistry and Physics of Dyeing, by W. P. Dreaper, F.I.C. (London: J. and A. Churchill; pp. xii. and 315; 10s. 6d. net).—The tendency of chemistry is to become more and more specialised, especially as regards its technical applications, but, on the other hand, the general principles of chemistry and physics underlying various technical processes are gradually being made clear, with the result that on every hand rational methods are slowly taking the place of the time-honoured ones, based on "rule of thumb." In his preface, the author points out that dyeing has lagged behind many other industries in this respect, and that even in the special treatises on the subject the description of working details is given the first place, and relatively little attention paid to the theoretical side; and he has written this book to supply the want. The work opens with an interesting introduction on the history of dyeing, which is followed by chapters on the properties of fibres, the nature of dyes, lakes, and mordants, and their action, evidences of physical and chemical action in dyeing, the part played by colloids in the processes and the action of light on the various operations, and the book concludes with a chapter on the methods of research and good indexes. In each section concise abstracts (with references) of the work done by others in the same field are given, so that the reader gains a complete survey of the whole ground. The book is excellently printed, and the author and publishers may be congratulated on the production of a work that will be most valuable to all interested in the industry of dyeing.

A Practical Chemistry Note-Book, by S. E. Brown, M.A. (Cantab.), B.A., B.Sc. (Lond.) (London: Methuen and Co.; pp. 56; 1s. 6d. net).—This note-book was originally designed for the use of candidates preparing for the qualifying examination of the Civil Service, but Mr. Brown is fully justified in concluding that it will also be found useful as an introduction to practical chemistry. Unlike many of the so-called "note-books," which are compiled solely for examination purposes, it does not do the thinking for the student; but while giving sufficient directions for the progressive exercises, it leaves spaces for descriptions of the

experiments and for diagrams of the apparatus to be drawn to scale. It is intended to supplement, but not to replace the demonstration of the teacher, and we can cordially recommend it as admirably adapted for this purpose.

MATHEMATICS.

Five-Figure Mathematical Tables, for School and Laboratory Purposes, by A. Du Pré Denning, M.Sc., etc. (London : Longmans, Green and Co., 1906; price 2s.).—This set of tables possesses several original features. The author notices that the mean differences become unwieldy in tables of logarithms of small numbers (*i.e.*, numbers near unity), and also in tables of antilogarithms of large numbers. His way out of the difficulty is to give antilogarithm tables for numbers up to 4 or logarithms up to .61, and logarithm tables for numbers above 4. The plan certainly saves two pages, which would be required if antilogarithms and logarithms of all numbers were given, and these two pages are devoted to antilogarithms and logarithms of reciprocals arranged similarly. The trigonometrical tables are not as clearly arranged as they might be, and we notice with regret that the "tabular" logarithms are denoted by Log, instead of by the old conventional L. If reforms of notation are desirable, let reformers turn their attention to the misleading forms, $\sin^{-1}$, $\cos^{-1}$, and $\tan^{-1}$, before they do away with such a non-misleading symbol as a capital L. The book contains physical and chemical tables, and those students who want to solve triangles without properly learning their trigonometry will find the tables of squares and cubes greatly to their liking.

METEOROLOGY.

Falmouth Observatory Meteorological and Magnetical Tables and Reports for the year 1905.—This Observatory is maintained by the Royal Cornwall Polytechnic Society, and is under the supervision of a committee of which Mr. Wilson Lloyd Fox is secretary. Mr. Edward Kitto is the superintendent of the Observatory. The Meteorological Office allows an annual grant of £250 for the carrying on of the meteorological records, and the Royal Society makes a grant of £53 and the British Association a grant of £50 towards the maintenance of the magnetic records. The present report not only gives the results of the meteorological observations for the year 1905, but also the averages for the 35 years, 1871-1905. The averages of the principal elements are as follows :—

	Temperature.		Rainfall.		Sunshine.	
Months.	Mean. °	Daily Range. °	Amount. ins.	No. of Rainy Days.	Amount hours.	No. of Sunless Days.
January ...	43.4	6.8	4.76	20	57.1	12
February ...	43.3	6.9	3.76	17	82.8	7
March ...	43.8	8.4	3.31	18	137.7	5
April ...	47.4	9.1	2.84	15	180.2	3
May ...	51.8	10.4	2.21	13	236.4	2
June ...	57.3	10.6	2.42	14	228.8	2
July ...	60.2	10.6	3.12	16	226.1	1
August ...	59.9	10.0	3.48	16	213.9	1
September ...	56.8	8.9	3.69	17	160.2	3
October ...	51.3	8.1	5.15	20	116.6	5
November ...	47.4	7.2	5.27	19	73.8	8
December ...	44.6	6.6	5.74	21	55.4	12
Year ...	50.6	8.6	45.75	206	1769.0	61

The mean magnetic declination for the year 1905 was 18° 8′.4 W. Falmouth Observatory is in latitude 50° 9′ 0″ N, and longitude 5° 4′ 35″ W.

NATURE STUDY.

We have received a copy of "Blackie's Nature-Knowledge Diary," compiled, with introductory notes on nature-study, by Mr. W. P. Westell, and sold at 6d. net. Careful record of all observations, no matter how trivial they may appear, is the point specially emphasised in the notes. The publishers, Messrs. Blackie and Son , Limited, offer prizes to school-children for the best-filled copies of the diary.

PHOTOGRAPHY.

Photographic Lenses; A Simple Treatise, by Conrad Beck and Herbert Andrews. 6th edition, revised (London : R. and J. Beck, Ltd., and Percy Lund, Humphries and Co., Ltd.; price 1s. net.).—The fact that fifteen thousand copies of this book have been called for shows that it has met with practical appreciation, and we think that it well merits the patronage it is receiving. The title is perhaps rather too broad, for one might imagine from the constant and exclusive references to lenses made by Messrs. R. and J. Beck, that this firm were the only makers of photographic lenses. But as Messrs. Beck make lenses of most of the ordinary types, including the most modern, the reference to their own instruments only does not notably limit the scope of the volume. The authors aim at providing a practical guide for practical photographers who do not wish to dip deeply into the subject of photographic optics. No one of ordinary intelligence can read the volume without getting a very good idea as to what lenses are, how they should be used, and what may generally be expected of them. The numerous illustrations show at a glance the effects described, and the kind of result that may be obtained under certain conditions. We are glad to see that spherical aberration is given as one of the elements that affects depth of definition, but we think that the authors might have departed from the too common custom of considering depth of definition in the centre of the field only. This is not a "practical" method of dealing with the subject. Another suggestion may perhaps be made, that, with regard to curvature of field, the character of the object might be defined, for it is not often enough realized that the image produced is generally, as it were, a solid image, neither curved nor flat, and bears no very simple relationship to what is properly called the field of the lens.

MISCELLANEOUS.

Natural Phenonema ; A Collection of Descriptive and Speculative Essays on Some of the By-Paths of Nature, by F. A. Black (Gall and Inglis).—This collection of ideas on some of the mysteries still unfathomed by man, includes chapters dealing with the variations of temperature, the peculiarities of the North Pole, the apparent enlargement of heavenly bodies near the horizon, weather cycles, the Sargasso Sea, the Zodiacal light, wind, varieties of Solar days, the rotation of the earth, and the diurnal variations of the barometer. Each of these subjects is clearly described, and its uncertainties discussed, while a number of diagrams, maps, and illustrations add to the lucidity of the descriptions. The frontispiece, a fanciful representation of the Zodiacal light, is the weakest feature of the book.

The Science of Dry Fly-Fishing, by F. G. Shaw (London : Bradbury, Agnew, and Co., Ltd., 1906; pp. xii. + 142; price 3s. 6d. net).—The observant angler has such abundant means of studying natural history, either as an essential part of his sport, or for its own sake, that we are quite glad to have the opportunity of noticing the work before us among books of a more strictly scientific nature. The author, whose name has previously been before the public on more than one occasion as a writer, appears to be a most accomplished fisherman, having gained the amateur championship in a recent fly-casting tournament. Whatever he states on the subject may, therefore, we presume, be accepted as thoroughly trustworthy, so that the book may be confidently recommended to lovers of the gentle art. An attractive coloured plate of a basket of trout from the Itchen forms the frontispiece to this exhaustive work.

MESSRS. HENRY SOTHERAN & Co. are publishing, under the title of "Bibliotheca Chemico-Mathematica," a valuable catalogue of works, chiefly rare or historical, on mathematics and astronomy, physics, aëronautics, chemistry, and other scientific subjects. The catalogue is being issued in parts, and in its complete form should be of great use to librarians or scientific men who wish to complete or fill up libraries. Among other works of special interest, we note the extremely rare first edition of the "De Revolutionibus," of Copernicus, which itself marked a "revolution" in thought; the first printed edition of "Euclid"; the first work on "Ballooning" (Faujas de St. Fond "Expériences de la Machine Aërostatique de MM. de Montgolfier"); and the first edition of "De Caux's "Raisons des Forces Mouvantes," which, according to Arago, contained the germ of the Steam Engine.

XUM

MICROSCOPY

Conducted by F. SHILLINGTON SCALES, B.A., F.R.M.S.

The Limits of Resolving Power.

IT is an accepted fact that there is a theoretical limit to the resolving power of all microscope objectives, this limit being strictly proportional to the numerical aperture of the objective, the numerical aperture itself being a method of notation which takes into consideration not only the angular aperture of an objective, but also the medium with which it is designed to be used, generally air, water, or oil, thus bringing dry and immersion lenses into one common and universal system of notation. It is on account of this theoretical limit of resolution that mere magnifying power, as such, offers us no real advantage, as we are unable to increase the amount of detail shown unless we can increase the aperture of our objectives. It is advisable to call attention to this limit of resolution, because there is some misunderstanding as to the advantages to be gained by increased magnification, more especially with regard to improvements in the image when highly magnified. To put it in another way, we may say that the power of a lens to show detail depends on its aperture, and on the refractive index of the medium with which it is used. This resolving power may be modified, however, to a certain extent by the wave-length of the light used, by the refractive index of the mounting medium, and even in certain cases by the obliquity of the cone of illumination, but the aperture of the lens and its medium are the two important factors. Given such resolution, we must have a certain magnification before we can see what the lens can show us, and an immersion lens of 1.4 N.A. (which is our present practical limit for ordinary work) requires quite a moderate magnification to show us all that it is capable of showing. Therefore, we hear nothing now of lenses like the $1/40''$ and $1/50''$ of former days, and high eye-piecing is likewise unnecessary. High eye-piecing has the further drawback of giving us, for various technical reasons, an increasingly imperfect image, and though ingenious methods have been devised to improve such a highly magnified image, it really shows us no more than is shown by the more moderate magnification, and does not, unfortunately, open out to us the new worlds of microscopic vision which some uninformed readers of the microscopic literature of the day seem to anticipate.

With regard to this theoretical limit, however, a paper by Mr. E. M. Nelson, in a recent issue of the Journal of the Royal Microscopical Society, though for the most part technical, contains suggestions which are of interest to workers with the microscope who are engaged in research of various kinds. In the first place Mr. Nelson reminds us that the actual theoretical limit of resolution is not fully determined, the physical nature of the image at the focal point not being yet fully understood, and, consequently, the mathematical deductions not agreeing with the practical results. It follows that estimates of measurement of structure based upon hitherto accepted mathematical tables require modification. Of course, this does not mean that we can see more than we are at present seeing, but that we may be to some extent in error as to our measurements of what we see, when based upon existing tables. Such tables are published by the Royal Microscopical Society, and reproduced in certain textbooks on the microscope, and they may require modifying accordingly. But Mr. Nelson's second practical suggestion is that these tables are based on the assumption that the worker uses a nearly full cone of illumination, which few workers do, as few lenses will stand such a cone, whilst, perhaps, fewer workers know how to obtain and utilise it, and, in fact, with the uncorrected Abbe condenser so commonly used it would be impossible. Mr. Nelson gives the specific instance of a biologist who has discovered some minute structure, and announces it as having been made with a $1/12''$ oil-immersion lens of 1.3 N.A., comp. ocular 12, × 1,500, and Gifford screen. A reference to the published tables would lead one to suppose that the capacity of resolution of this new discoverer's apparatus was 135,800 lines to the inch, and that the structure is smaller than it really is, because he has omitted to inform us that his condenser either would not give a full cone, or was stopped down say to a $\frac{3}{4}$-cone, with a consequent limit to 1 N.A., and a limit of resolution of 70,000 lines to an inch. Mr. Nelson proposes to obviate all this by the suggestion that the observer should, without disturbing either his illumination or any of his adjustments, place a Grayson's band-plate on his stage, and see which band was resolved, so that in the above case he would add to his published data the words "Grayson band, 60,000," and so do away with all ambiguity, and make it apparent that either a small cone of illumination was employed, or that his objective, apparatus, or eyesight must have been defective.

Royal Microscopical Society.

October 17.—An old portable microscope made by Dollond, presented to the Society by Major F. R. Winn Sampson, was exhibited. This microscope, like others of the same period, was a modification of Cuff's "Newly-Constructed Double Microscope." Instead of a box-foot it was hinged on a bracket in the bottom of the case, which latter thus formed the base of the instrument and admitted of either a horizontal or upright position. One end of the case is hinged so as to let down and allow the mirror to project when the microscope is in a raised position, the instrument lying flat when the case is closed. The stage is focussed by a rack and pinion instead of the body. The eye-lens of the ocular is compound, and consists of two lenses, the one next the eye being plano-convex, and the other double convex. The instrument is the only example of its type in the Society's collection. It resembles a larger microscope which belonged to Sir David Brewster, and which is now in the British Museum. A small pocket microscope, presented by an anonymous donor, was also exhibited. It is a brass box about $1\frac{7}{8}''$ high and $1\frac{1}{8}''$ in its greatest diameter. It contains a simple microscope for viewing small insects impaled on a steel point, and two other magnifiers, and a diminutive line box. These magnifiers were not uncommon 30 or 40 years ago, and were frequently made of ivory, and were probably the precursors of the modern pocket lens. An immersion spot lens by Reichert was exhibited, suitable for high powers and for showing ultra-microscopic particles. Messrs. W. Watson and Sons exhibited a new metallurgical microscope, and the new Cathcart Darlaston microtome, as described in "KNOWLEDGE" for November, page 597. A paper by Mr. James Murray on "Some Rotifera from the Sikkim Hima-

laya" was read in the absence of the author, and was illustrated by large-scale drawings and mounted specimens. Mr. J. M. Coon read a paper on *Connuvia sepula*, illustrated by lantern slides and mounted specimens. Mr. A. E. Conrady gave a summary of his paper on an early criticism of the Abbe theory made by Dr. Altmann in 1880. Dr. Altmann endeavoured to extend the Helmholtz theory by maintaining that the image should be considered as built up of diffusion discs such as Helmholtz had dealt with in his paper of 1873. This paper brought a vigorous reply from Prof. Abbe, in which he added very considerably to the previously published account of his theory, and he laid stress on the difference between a self-luminous object and one illuminated artificially.

Quekett Microscopical Club.

October 19.—Mr. C. F. Rousselet, F.R.M.S., gave a corrected description and exhibited a specimen of the rare rotifer *Tetramastix opoliensis*. Mr. Jas. Burton read a paper, "On the Reproduction of Mosses and Ferns." The position in the vegetable kingdom of these two groups and of their near allies was pointed out. The various methods of reproduction met with among plants were described, and attention was directed to the fact that in the mosses and ferns *both* the non-sexual and sexual methods were developed to the utmost extent in one life-cycle, which cycle is spoken of as a whole as "An Alternation of Generations." Details of the methods of reproduction obtaining in the two groups under notice were given at length, and the differences pointed out. The capsule of the moss was shown to be the counterpart of the fern-plant, while the prothallus corresponded with the evident leafy stem of the moss. The structure of the various organs, etc., involved was described. In these two groups the two methods of reproduction are balanced, neither is developed at the expense of the other, and the ferns and mosses were cited as guides to the processes that occur in the other divisions of organic nature.

Cytology of Bacteria.

The Journal of the Royal Microscopical Society gives a summary of some investigations by A. Guilliermond, into the structure of *Bacillus radicosus*, which is well suited for the purpose by reason of its large size, and which have been recently published in *Comptes Rendus*. In a less than ten-hours-old culture, after fixation in Zenker's fluid, and staining with iron-hæmatoxylin, almost every cell shows a large, deeply-stained central granule, which represents the first appearance of the site of transverse fission, and is formed by the union of two small lateral granules apparently derived from a concentration of the cytoplasm; this large granule, or bi-concave disc, divides into two coloured bands, through which the division of the two cells is effected. After 10 to 12 hours the cytoplasm becomes vacuolated and filled with fine stained granules of varying size, and later shows an alveolar structure filled with fine granules resembling granules of chromatin. The spore appears at one of the poles as a small, deeply-stained granule; it enlarges, takes an oval form, and becomes surrounded by a thick membrane which prevents the penetration of stains. The spore appears to be derived in part from a condensation of the granules of the cytoplasm.

The author concludes that a true nucleus does not exist in a bacterium, and that such as have been described by various authors are misrepresentations, but agrees with Schaudinn that bacteria contain a chromatin more or less mixed with the cytoplasm, differentiated at times and constituting the greater part of the spore.

Demonstrating Life History of Leucocytes.

A recent issue of the Royal Society's *Proceedings* contains a method devised by C. E. Walker, for demonstrating the life-history of leucocytes. He fixes the material with Flemming's fluid (strong formula), Hermann's fluid, acetic acid and absolute alcohol, corrosive sublimate and acetic acid, and strong formic acid. The author remarks that great care must be taken with the processes of fixation, dehydration, imbedding, staining, etc. Extremely small pieces of tissue should be placed in the fixative within about a minute of the death of the animal or removal from the living body. Dehydration should be carried out in short stages, an increase of 10 per cent. of alcohol being perhaps best. This does not apply to tissues fixed in acetic acid and alcohol, or strong formic acid (40 per cent.), from which the tissues are transferred immediately to absolute alcohol. At the same time, it is necessary that the tissues should not be left in alcohol (under 80 per cent.) for more than two or three hours after fixation. In imbedding, no higher temperature than 45° C. should be used. Throughout the processes of staining and mounting, the greatest care must be taken that the sections do not become even partially dried upon the slides. The author states that it is necessary to use a 10-inch tube microscope, with monochromatic light and apochromatic objective and eye-piece, in order to obtain the best definition with immersion lenses, and 27 or even 40 compensation oculars, but he adds that anything approaching this is impossible with the ordinary short-tube—a somewhat incomprehensible statement.

Microscopical Slides.

Messrs. Clarke and Page, of Leadenhall Street, have sent me their new list of microscopical slides, microscopes, objectives, and accessories. I have before called attention to these slides, which are similar to those mounted and sold by Mr. Hornell, and many of them are of great beauty, and moderate in price. Amongst the slides are some prepared and mounted without pressure, including slides illustrative of marine zoology, such as *Bugula turbinata*, and Annelidæ, mounted fully expanded, triple-stained palates of molluscs, mounted for polariscope, and a particularly fine slide of the head of a blow-fly, also mounted without pressure, and showing the structure of the proboscis in a way very different to its ordinary appearance when mounted.

Studies in Micropetrography.

Mr. E. Howard Adye is issuing a series of studies in micropetrography, dealing with some 48 different specimens, somewhat on the lines of his recent "Atlas," each section being fully described, with bibliographical references, and with a large coloured illustrative plate, with key. In addition, actual chips of the rocks described can be obtained for comparison and examination. Further particulars can be obtained from the publisher, Mr. Robert Sutton, 43, The Exchange, Southwark, S.E.

[Communications and enquiries on Microscopical matters should be addressed to F. Shillington Scales, "Jersey," St. Barnabas Road, Cambridge. Correspondents are requested not to send specimens to be named.]

XUM

The Face of the Sky for December.

By W. SHACKLETON, F.R.A.S

THE SUN.—On the 1st the Sun rises at 7.45 and sets at 3.53; on the 31st he rises at 8.9 and sets at 3.58. The equation of time on the 25th is only 7 seconds, and for ordinary purposes is negligible.

Winter commences on the 22nd, when the Sun enters the sign of Capricorn at 6 p.m. Sun spots have lately been comparatively scarce; at the time of writing two small groups are visible on the solar disc.

The positions of the Sun's axis and of the centre of the disc are given below:—

Date.	Axis inclined from N. point.	Centre of disc N. or S. of Sun's Equator.	Heliographic Longitude of Centre of Disc.
Dec. 2 ..	15° 50′E	0° 35′N	173° 10′
,, 12 ..	11° 42′E	0° 42′S	41° 24′
,, 22 ..	7° 5′E	1° 57′S	269° 40′
Jan. 1 ..	2° 14′E	3° 10′S	137° 57′

THE MOON:—

Date.	Phases.	H. M.
Dec. 9 ..	☾ Last Quarter	1 45 a.m.
,, 15 ..	● New Moon	6 54 p.m.
,, 22 ..	☽ First Quarter	3 4 p.m.
,, 30 ..	○ Full Moon	6 44 p.m.
Dec. 1 ..	Apogee	6 24 p.m.
,, 15 ..	Perigee	2 30 p.m.
,, 28 ..	Apogee	6 36 p.m.

OCCULTATIONS.—The following table gives particulars of the principal occultations visible at Greenwich before midnight:—

Date.	Star's Name.	Magnitude.	Disappearance.		Reappearance.		Moon's Age.
			Mean Time.	Angle from N point.	Mean Time.	Angle from N. point.	
			p. m.		p. m.		d. h.
Dec. 2	χ^3 Orionis	5·1	5 33	111°	6 19	231°	16 9
,, 3	ζ Geminorum ..	var.	10 36	23°	11 10	328°	17 14
,, 19	γ Capricorni ..	3·8	4 40	104°	5 39	215°	3 22
					a. m.		
,, 25	μ Ceti	4·4	10 59	55°	12 12	263°	10 4
					p. m.		
,, 28	m Tauri	5·1	9 35	67°	10 57	266°	13 3
,, 29	χ^2 Orionis	5 9	7 47	108°	8 51	228°	14 1

THE PLANETS.—Mercury (Dec. 1, R.A. 16h 15m; Dec. S. 19° 46′; Dec. 31, R.A. 17h 19m; Dec. S. 22° 37′) was in conjunction with the Sun on the 30th of last month, and is, therefore out of range during the early part of this month. The planet is at its greatest westerly elongation of 21° 35′ on the 18th, when he is a morning star in Scorpio, rising nearly 2 hours before the Sun.

Venus (Dec. 1, R.A. 16h 17m; Dec. S. 22° 26′; Dec. 31, R.A. 16h 2m; Dec. S. 16° 20′) is a morning star in Scorpio rising about 6 a.m. near the middle of the month. On the 31st the planet rises at 4.48 a m., or nearly 3½ hours in advance of the Sun, on this date, the telescope appearance is a very thin crescent, 0·08 of the disc being illuminated.

Mars (Dec. 1, R.A. 13h 16m; Dec. S. 6° 47′; Dec. 31, R.A. 14h 26m; Dec. S. 13° 21′) is a morning star, in Virgo and Libra. Near the middle of the month the planet rises about 3 a.m.; the apparent diameter of the disc is only 4″·6, which is too small for useful observation with telescopes of moderate power.

Jupiter (Dec. 1, R.A. 6h 41m; Dec. N. 22° 58′; Dec. 31, R.A. 6h 24m; Dec. N. 23° 14′) is a brilliant object in the evening, looking east; towards the end of the month he is due south at midnight, being in opposition to the Sun on the 28th. The planet is describing a retrograde path in Gemini, about 8° north of the star γ Geminorum.

The planet is very favourably situated for observation before midnight, and forms with his belt-like markings and bright moons a most interesting object even in very small telescopes.

On the evening of the 30th, the moon will appear near the planet.

The equatorial diameter of the planet on the 15th is 47″·5, whilst the polar diameter is 3″·1 smaller.

Saturn (Dec. 1, R.A. 22h 44m; Dec. S. 10° 10′; Dec. 31, R.A. 22h 50m; Dec. S. 9° 27′), is situated about 2° south of the star τ Aquarii. The planet is due south about sunset, and well placed for observation during the early part of the evening; near the middle of the month he sets about 10.30 p.m. The ring, which can be seen in small telescopes with moderate powers, appears slightly open as we are looking at an angle of 6°, on the northern surface.

On the 5th, the outer major and minor axes of the ring are respectively 39″·9 and 4″·3, whilst the polar diameter of the globe is 15″·8. The Moon will appear in proximity to the planet on the evening of the 20th.

Uranus (Dec. 15, R.A. 18h 34m; Dec. S. 23° 32′), is in conjunction with the Sun on the 31st, and hence is unobservable.

Neptune (Dec. 15, R.A. 6h 51m; Dec. N. 21° 2′) rises about 5.30 p.m. near the middle of the month, and is due south about 1 a.m. The planet is situated in Gemini, about 1½° N.W. of ζ Geminorum, but in small telescopes without setting circles it is difficult to identify from the numerous small stars in the same field of view, but he can be detected by his motion if observations are made on several successive nights. The planet is in opposition to the Sun on the 31st.

METEORS:—

The principal shower of meteors during the month is the Geminids, Dec. 10th to 12th; the radiant is near Castor, in R.A. VIIh 12m, Dec. + 33°. The meteors are short and quick, and difficult to record accurately.

VARIABLE STARS:—

Minima of Algol may be observed on the 5th at 11.17 p.m., the 8th at 8.6 p.m., the 11th at 4.55 p.m., the 28th at 9.48 p.m., and the 31st at 6.37 p.m.

o Ceti (*Mira*) is due at a maximum on the 20th, but observations should be made some weeks on either side of this date as the period is uncertain.

TELESCOPIC OBJECTS:—

Double Stars:—1 Pegasi 21h 17·5m, N. 19° 20′, mags. 4·5, 8·6; separation 36″·2.

π Andromedæ 0h 31·5m, N. 33° 11′, mag. 4·0, 8·0; separation 36″·3.

α Piscium 1h 56·9m, N. 2° 17′, mags. 3·7, 4·7; separation 3″·6.

ι Trianguli 2h 6·6m, N. 29°50′; mags. 5, 6·4; separation, 3″·5.

Clusters:—(H VI. 33, 34). The Perseus clusters visible to naked eye and situated about midway between γ Persei and δ Cassiopeiæ. These magnificent clusters are described by Smyth as "affording together one of the most brilliant telescopic objects in the heavens."

(M. 34.) A mass of small stars about the 8th magnitude; not very compact. The cluster is just perceptible to the naked eye about 5° N.W. of Algol.

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